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A Clue to the Investigation of the Control of Breathing in Fish by Means of Electrical Activity in the Muscle Located on the Regions of the Gills*)**)

(*With 6 Text-figures*)

JIHEI KONISHI

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The autonomous activity of the respiratory center and the reflex effect of the peripheral receptors were discussed well by many workers. ADRIAN and BUTENDIJK, working on gold fish, recorded the potential change of the vagal lobe with the slow frequency which seems to be synchronized with the breathing rhythm, and have made a valuable contribution by proving the presence of inherent rhythm of respiratory center. Some one offered the evidences to show that the control of normal breathing in fishes was dominantly reflex, originating from the peripheral receptors. In higher vertebrates, however, it is no doubt that the normal breathing are performed homoniously by the autonomous excitation of central neuron, associating with the control of breathing by the incoming impulses from peripheral receptors. Similary in fishes, as reported by Lutz, it seems that the author proposed that the respiratory center is autonomous, but that it is influenced by the gas content of the blood and by peripheral stimulation. However, BETHE perfused the gills of elasmobranch fishes with oxygen-free sea water saturated with carbon dioxide, and found that the rate and strength of respiration remained unaltered for about forty minutes. He also paralyzed the peripheral receptors of the gills and pharynx with cocaine and obtained a cessation of respiration. He therefore concluded that the gas content of the blood is of no influence to fishes, and that breathing is caused by peripheral stimulation. Recently, POWERS and CLARK observed the response of respiration in fishes by sectionings the branches of the IXth and Xth cranial nerves just central to the gills and reported that their observations do add evidence to the dominance of impulses through the former nerves over all breathing movements.

The present paper is concerned with the earlier work in showing the electromyographic activity detectable from the surface of the gill, and the relationship to the central activity and also a clue to the elucidation of the

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** Directed by Professor N.Y. Kawamoto.

control mechanism of breathing and the respiratory reflex by the electromyogram.

Method

Vigorous specimens of *Carassius auratus* (L.), average body length, 6 cm., taken during the months of September and October, were used. The fish is taken out of water and then placed lateral side up on a fish holder. The fishes were not anesthetized and their gills were usually not perfused. After exposing the gills, various sets of bipolar lead muscle potentials were recorded from gill surface (Fig. 1). Recording electrodes consist of a pair of nonpolarizable Ag–AgCl wire. The four stage amplifier system and electromagnetic oscillograph were employed. For the recording of breathing rhythms, the metal hook inserted through the operculum at the cutting edge and by means of a light leber its movements were transferred to electrical changes by the electrical circuit. The voltage changes due to movement of the leber were amplified by a R-C-coupled amplifier (time constant, 1 sec).

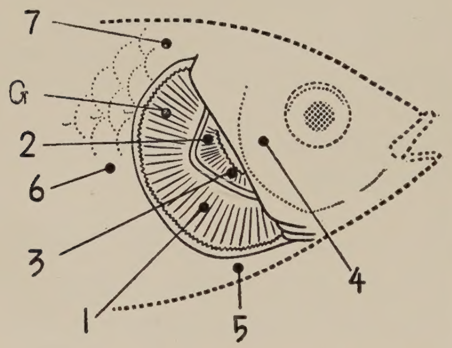

Fig. 1. Diagram showing various electrode positions. The numbers, 1–7, show the different loci used for the reference electrode, whereas G is the constant locus of the active electrode.

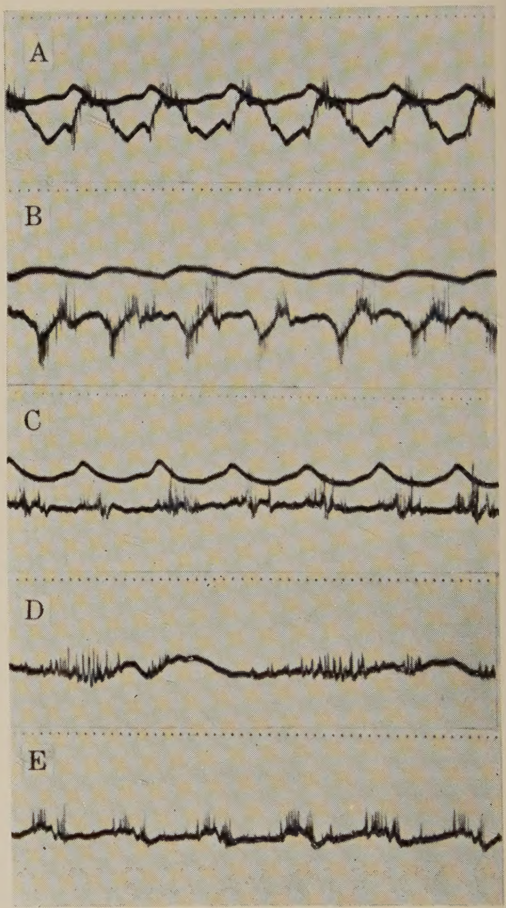

Fig. 2. Rhythmic discharges from the muscle of gill. A and B, lead G–1. C, leads G-4 (5, 6, 7). D and E, lead G–2. Negative deflection upwards. In the records, A, B and C, the upper curves show breathing rhythms. Inspirations are represented by upward movement. Time in 0.1 sec.

Experimental Results and Discussion

The slow rhythmical changes interpreted as being caused by the impedance changes due to the movement of electrodes accompanied by breathing movement

were almost observed besides muscle discharges. These slow potential changes, however, did not impede the recording of muscle activity. When the active electrode was placed on the dorsal portion (G) of the first gill lamella and the reference on the ventral portion (1), it was nearly always possible to detect the two groups of bursts of muscle discharges of opposite deflection, synchronous to breathing rhythms (Fig. 2 A, B). The commonest was the occurrence of these features, but in spite of the same electrode position only one group of discharges was sometimes recorded. It certainly supports the view that we were concerned with the myographic activity and not with the discharge of branchial nerve because the action potentials are clearly of long duration compared with action potential wave in a nerve, though we could not demonstrate anatomically the two kind of muscle, located at the gills, concerned with the generation of each electrical activity. It then became evident that these muscle potentials originated from the muscles localized on the gill region as shown from the following experiments. If active electrode is on the gill region, the deflections of each spike potential always indicated negativity at this electrode wherever the other may be (Fig. 2 C). The muscle discharges identical with the above can also be detected from the surface of the isolated gill and cease in few minutes after isolation (Fig. 3). They were usually continuous discharges, except for the rare record in Fig. 3 B, in which was shown rhythmic discharges, and were usually elicited from two groups of different muscle, and in some case only one group of muscle. If one electrode is on the gill lamella and the other on the gill-raker (leads G–2 in Fig. 1), acrossing gill-arch, the deflection of which the gill lamella region becomes negative to the other always appeared (Fig. 2 D, E). It is generally agreed that the excited or active region becomes temporarily depolarized and potential gradients are set up so that the excited region becomes negative to the neighbouring points. Thus it might be concluded that the action potentials recorded were caused by the muscles of gill associated with the respiratory movement.

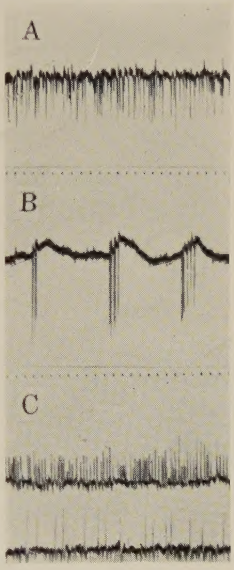

Fig. 3. Discharges from the muscles of isolated gill. Negative deflection upward. Time in 0.1 sec.

The experiments recorded the breathing rhythms with the muscle discharges simultaneously, show that the discharges of which the main wave indicates positive deflection (called P-discharge) occur during the period starting from the beginning point of active expiratory movement (cf. Sakamoto '22) up to the phase of maximal expiration. The discharges with negative deflection (called N-discharge) occur from the phase of maximal expiration up to the inspiratory phase. The

duration of the N-discharge is usually longer than that of the P-discharge. In some cases, however, N-discharge appeared during latter half of the inspiratory phase. At this time, expiratory and inspiratory movements indicate the closing and opening of operculum respectively. In view of these patterns of discharge, two groups of muscle discharge can be recognized from the muscle activity involved in expiratory and inspiratory movement. In normal breathing, the pause of muscle discharge is usually observed during the passive expiratory and inspiratory phase.

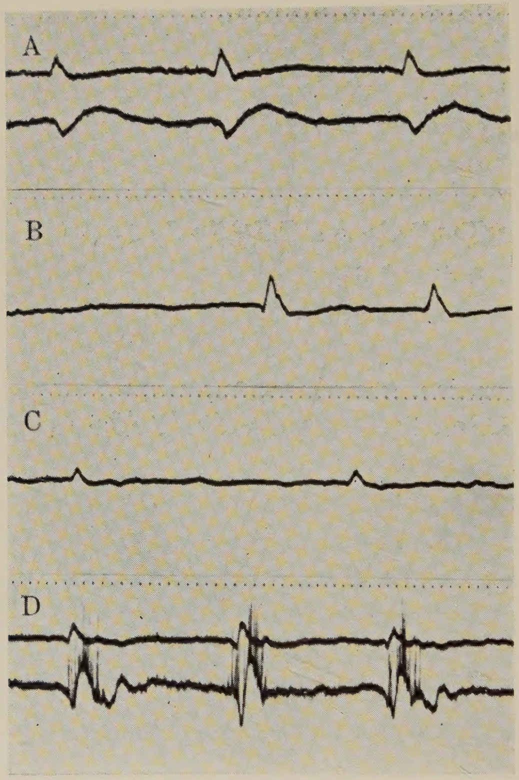

Fig. 4. A, B and C, rhythmic potential waves from the intact (A, B) and isolated vagal lobe (C) D, simultaneous records of the potential waves from the vagal lobe and the discharges from the muscles of gill. Negative deflection upwards. Time in 0.1sec.

It may have to depend on further future's works to clear up the role of the center to the mechanism of alternation of respiratory movement and the presence of sub-central control mechanism and also the reflex mechanism through the peripheral receptors, though the respiratory center is proved to be autonomous by ADRIAN and BUTENDIJK.

However, since the activity of respiratory muscle may be under the control of the center, it may be possible to find to a certain extent indirectly the role of center to the control of respiration and also the reflex mechanism from the mode of muscle activity. In the isolated brain stem, as done by ADRIAN et al, the simultaneous recording of central activity and of breathing rhythm can not be performed, hence the simultaneous recording of potential changes of the intact vagal lobe and the muscle of gills were made and the possibility of analysing the respiratory movement from the central activity by the index of muscle activity was discovered. Fig. 4 A, B show the rhythmic potential waves from the exposed brain stems of intact animals, and it seems to be difficult to record exactly from intact state owing to the movement of electrodes. Fig. 4, C shows the record from the isolated brain stem. The negativity of these potential waves does not strikingly change by the reference electrode positions if grid electrode is on the vagal lobe

and it was concluded that each wave is caused by the vagal lobes developing a negative potential with respect to other parts of the brain stem. Fig. 4, D shows an example of simultaneous record of potential change of the center with discharge of the gill muscle. The synchronization between them is clearly visible, but in this record no P-discharge can be observed unfortunately. This record and the above-stated mode of muscle discharge show that the phase of N-discharge volley, the that is inspiratory phase, agrees with the phase that the potential change of the center arises. In other words, excitation of respiratory center seems to be induced on the phase just before inspiration.

From the results of the author and also of ADRIAN et al, different center corresponded to the so-called inspiratory and the expiratory center in mammals can not be detected in fish so far the electrical changes is concerned, and only one kind of rhythmic potential wave in appearance is observed from the vagal lobe. It comes then be a question, what is the mechanisms of alternation of respiration from expiration to inspiration and vice-versa presenting in fish. In order to solve this problem we have nothing to answer exactly, but it might be

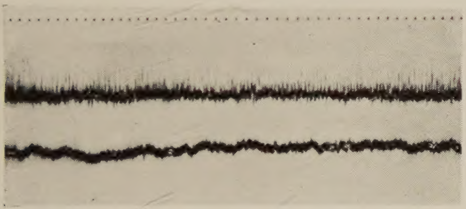

Fig. 5. Continuous discharges from the muscles of gill of preparation which is in apnoea. Lower curve, activity of respiratory center. Time in 0.1 sec.

Fig. 6. Reflex respiratory responses caused by touch stimulation of the gill of preparation which is in apnoea. Downward deflection denotes expiration; arrows, gill touched. Time in 1 sec.

considered that the P-discharge, is an expiratory movement, occurring at just the beginning of potential change of the center and the inspiratory movement at the maximal level. The alternation of respiration may be controlled by the following mode of the discharges from the efferent fibers located within the center: the efferent expiratory nerve fibers in the center discharge in the beginning of the central excitation and are then followed by the dischages of the inspiratory fibers. It can therefore be inferred that the alternation of respiratory movements may be caused by the difference of threshold between expiratory and inspiratory fibers and by the refractory period of concerned fibers.

During the course of experiments, the apnoea appeared to be at the neutral level rather than the expiratory apnoea or the apnuesis was sometimes observed. As was shown in Fig. 5, there appear continuous discharges consist of the gill-negative potentials in spite of apnoeal state and it may be clear that the respiratory center is at continuous excitatory state even if the breathing ceases

and also that the apnea indicates to be apneusis. During the apneusis, moreover, the tactile stimulation to the gill region evokes a deep passing inspiration (Fig. 6). It may thus be expected that the role of the center to the alternation of breathing and also of the response of the center to peripheral stimulation is possible to elucidate by analyzing the mode of muscle activities obtained in not only the reflexly but also normal breathing.

The author's many and hearty thanks are due to Prof. N. Y. KAWAMOTO for his helpful criticism and advices, and especially to Mr. Y. MAEGAWA and Mr. K. YAMAZAKI for their much useful discussion.

Summary

1. Two kinds of action potentials, in the form of burst dischages, which may correponded to the muscle activities involved expiratory and inspiratory movements were recorded from the surface of gill lamella of intact fish, *Carassius auratus* (L.). These muscle discharges could also be detected from the isolated gills.

2. The simultaneous recording of the potential waves in the respiratory center with the muscle discharges from the gills showed the marked correlations between them.

3. The role of the center to the breathing was discussed from the responses of muscles which may represent the central activity.

4. It was suggested that the active expiratory movement may occurrs at the beginning of the development of the central activity and the inspiratory movement around the maximal excitation of the center.

Literatures

ADRIAN, E. D., and BUTENDIJK, F. J., 1931. J. Physiol **138**, 104.
BAGLIONI, S., 1907. Zeitschr. f. Allg. Physiol. **7**, 177.
BASUGI, A., 1919. Kyoto Igaku Zassi, **17**, 1266. (in Japanese)
BETHE, A., 1925. Handbuch norm. path. physiol., **2**, 1.
BLACK, E. C., 1951. Univ. Toronto Biol. Series, No. 59, 91.
FUKUHARA, T. and OKADA, H., 1956. J. Physiol. Soc. Jap., **18**, 249. (in Japanese)
LUTZ, B. R., 1930. Biol. Bull. LIX (2), 170.
———, 1930. Biol. Bull. LIX (2), 179.
OGUCHI, K., 1954. J. Physiol. Soc. Jap., **16**, 771. (in Japanese)
POWERS, E. B. and CLARK, R. T., 1942. Amer. J. Physiol. **138**, 104.
SAKAMOTO, S., 1922. Kyoto Igaku Zassi, **20**, 141. (in Japanese).
STELLA, G., 1939. J. Physiol., **93**, 263, **95**, 365.
TOKIZANE, T., KAWAMATA, K. and TOKIZANE, H., 1952. Jap. J. Physiol., **2**, 232.
YOSHIDA, T., 1919. Kyoto Igaku Zassi, **17**, 1327. (In Japanese)

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Respiratory Reflex Response in Fish*)**)

(*With 5 Text-figures*)

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In the previous paper of this journal (1957) the author described the experiments in which I recorded oscillographically the electrical activity of respiratory center and the electromyogram of muscle located in the regions of the gills of intact fish. The electrical potential waves recorded from the vagal lobe is usually monophasic and of smooth contour and seems to be homogeneous property so far the electrical appearance is concerned. Neither the wave corresponded to the inspiratory or the expiratory center can be at present recognized in fish and it is more difficult to comment upon the role of respiratory center to the alternation of respiration.

POWERS and CLARK showed that the control of normal breathing in fishes is dominantly reflex orginating in the receptors located at the regions of the gills and innervated by the IXth cranial nerves and also described, that the observation add evidence to the views holding to the presence of an apneustic center and its inhibition be incoming impulses over the IXth and Xth nerves. LUTZ, working on elasmobranchs, obtained the respiratory inhibitory reflex from the gills and various parts of the body surface. His records showed that the apnoea evoked may be in apneustic though it was not mentioned. It was generally recognized in higher vertebrates that the cutaneous pressure stimulus and touch stimulus cause the inhibitory and excitatory effects respectively upon the muscle tone, and these phenomena were called by TAKAGI "Skin Pressure Extrapyramidal Reflex". These reflex effects were also obtained on the respiratory movement.

This paper is concerned with the respiratory reflex in fish caused by the touch stimulation, and I have now studied the role of center to breathing by means of the index of muscle discharge in experiments to be described in the present paper.

Experimental Method, Results and Consideration

A description of the operative procedure, and the setting up of the prepa-

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ration for the testing and electrical recording of its responses has been given in my previous paper (1957). All the results described below were obtained by

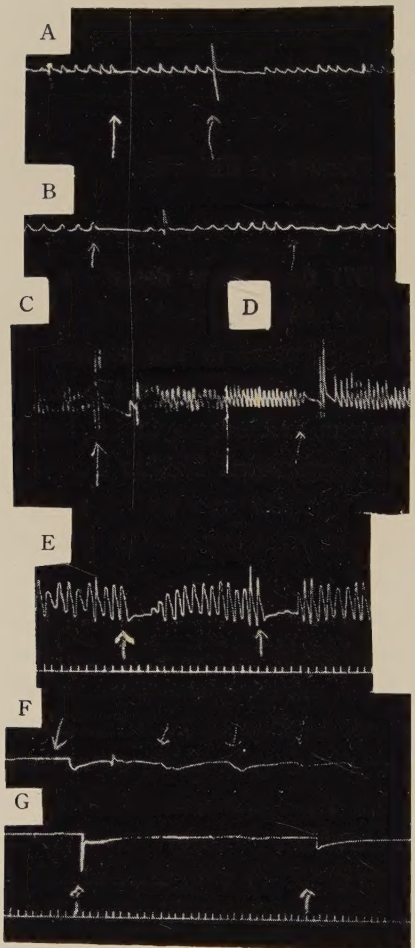

Fig. 1. Records of reflex respiratory responses caused by touch stimulation of gill of normal breathing (A, B, C, D, E) and apnoeal preparation (F, G); arrows denote gill touched. Upward and downward deflections indicate expiration and inspiration respectively. Time in 1 sec.

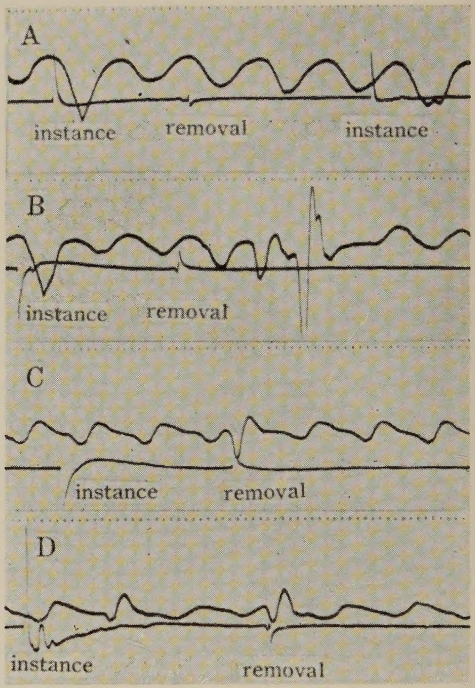

Fig. 2. Records of reflex respiratory responses caused by touch stimulation. Upper curve is breathing record; lower curve, stimulus signal. Time in 0.1 sec.

the touch stimulation applied to the gill lamella, recording the dischrge of the muscle of gill simultaneous with breathing rhythm. The stimulus was made by a silver wire. Fig. 1 shows the effects of touch stimulus on the opercular movements, in which the fish breathed normally and was in apneusis. In the case of normal breathing, following various responses were obtained: 1) when stimulated, a passing (A) or double or more repeated deep breathing (C), which began with inspiration, followed by apneusis, 2) the respiratory reflex that the apneusis occurred immediately following stimulation (B, E), 3) the reflex only at cessation of stimulus, no immediate response (B, D), were observed. Fig. 1, F, G indicate examples in which the touch stimulus was applied to the preparations in apnoea state and the occurrence

of deep inspiratory movements are observed. The response evoked by the stimulus in the preparation of normal breathing is entirely the same as the so-called redoublement inspiratoire or the clearing motion in shape, and the response, as shown by SAKAMOTO, is seen to be consisted of an extra inspiratory movement occurring in place of active expiration from the neutral position following a passive expiratory movement. The clearing motion observed in normally breathing fish, however, may not be reflex. In some preparations, this type of reflex is evoked only at the instance or removal of stimulus and without the appearance of apnoea as is shown in Fig. 2. Fig. 2 shows the simultaneous records of touch signal and breathing movement. When the touch stimulus was given at the phase of maximal expiration, larger inspiration than in normal was elicited immediately following stimulus and in consequence of it, the pattern of reflex do not shows clearing motion type (Fig. 2, A, B). No responses at the removal of stimulus were observed in Fig. 2, A, but in B there were two successive respiratory reflexes of clearing motion type several minutes after removal of the stimulus. The reflex were also sometimes observed several times after the stimulation as was shown in Fig. 2, D. In view of these results it was concluded that the touch or removal of stimulus, gives rise to inspiratory reflex and it was fortified by the fact that the same effect could be obtained in the preparation which is in apnoea as described in the previous paper. Moreover, the experiments show that the stimulation must to be applied around the neutral position followed a passive expiratory movement in order to cause the respiratory reflex of clearing motion type. If it did not fit to that, a deep inspiration appears only at the instance

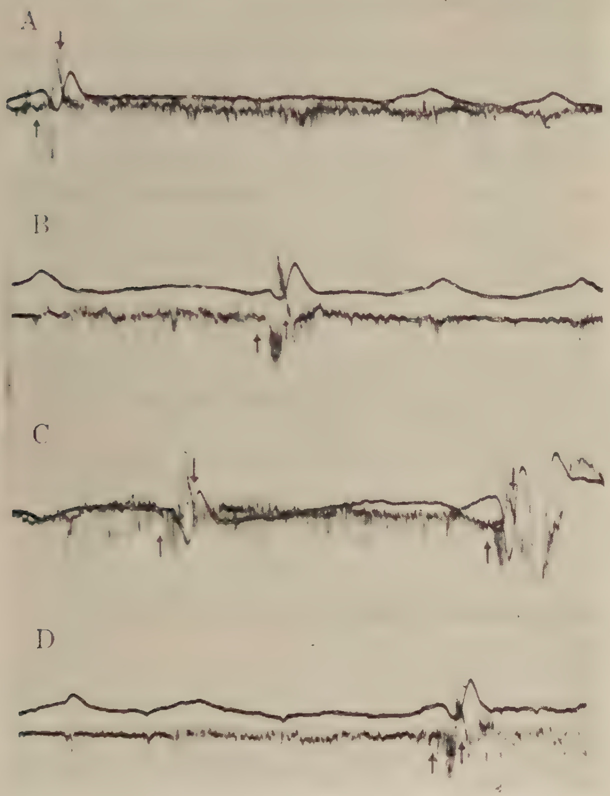

Fig. 3. Discharges from the muscles of gill in the reflex respiratory responses. Arrow indicates the pause of discharge. Time in 0.1 sec.

of stimulus as in Fig. 2, A, B or the stimulus have no effect at all as in C.

It may be possible to consider to a certain degree the role of the center to the reflex as well as the control mechanism of the center to normal breathing by means of simultaneous recording of the reflex respiratory movement and of the muscle discharge of gill. The records represented in Fig. 3 show the effects of touch stimulation to the preparation that breathed normally, with rhythmic appearing muscle discharges: A – reflexes of clearing motion type followed by apneusis was observed only at the instance of stimulation. B – no response at the instance of stimulation but there was at the removal of stimulus. C – response appeared between the phase of stimulation and removal of stimulus. There appear obvious volley of muscle discharges synchronized to the early inspiratory phase of the reflex movement and also continuous muscle discharges during apneusis. These results proved entirely that the respiratory center is in excited state during the stimulation even continued though the breathing has ceased. The apnoea of that records is likely to be not the true apneusis, owing to the appearance of two kinds of muscle discharges, corresponding to the inspiratory and the expiratory muscle. In Fig. 3, C, however, it is clearly observed that the early phase of the apnoea is at inspiratory, but the latter half at expiratory, and that the inspiratory muscle discharges in the inspiratory phase, but no inspiratory muscle discharges in the latter. When the stimulus was given to the preparation which is in apneustic state, there was the occurrence of a deep inspiration and an increase in frequency of inspiratory muscle discharges (Fig. 4, A).

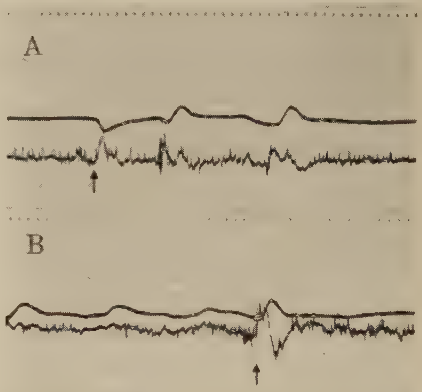

Fig. 4. Record A shows pattern of discharges from the muscles of gill of preparation which is in apnoea in the reflex respiratory responses. Record B shows apneusis caused by touch stimulation; arrow denote gill touched. Time in 0.1 sec.

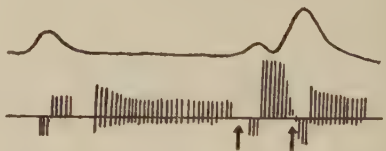

Fig. 5. Schematic drawing of pattern of discharges from the muscles of gill in the reflex respiratory response. Upper curve, breathing breathing rhythm. Lower curve, muscle discharge. Arrows indicate the pause of discharge.

Thus the fact that the touch stimulus causes the inspiratory movement suggests that the respiratory center is excited by incoming impulses and then inspiration occurs. In view of the results described previously (1957) in which the potential changes of the center occur dominantly at the inspiratory phase, it is suggested that the inspiratory movement may perhaps occurs at the maximal

phase of central excitation, and the maintenance of central excitation causes the apneusis.

Fig. 5 is prepared for the explanations of respiratory reflex movement in detail. In the passive expiratory phase iust before of reflex inspiration and also the reflex expiratory phase, two short pauses followed by expiratory muscle discharges were observed, and following them, the inspiratory muscle discharges.

The clearing motion, therefore, is no more than the response consisted of rapidly repeated breathing. Since the silent period seems to show the lowering of central activity, it should be concluded that in order to occurring expiratory movement the central activity must to be inhibited following inspiration, and then the expiration occurs at the initial phase of the development of central activity following the pause. It is suggested that the alternation of respiration may due to the rising and lowering shift of the activity of respiratory center. In the Fig. 4, A in which the deep inspiratory reflex was evoked by the stimulus in the preparation continued apneusis, there appears only increase in the frequency of inspiratory muscle discharges and has no activity of expiratory muscle. This may be interpreted as due to maintenance of enhanced central activity beyond the conditions of expiratory muscle response because of apneusis, and also indicates again that the lowering of central activity should precede the occurrence of expiration in either normal breathing or reflex. The touch stimulus generally recognized to promote vital function, causes in this case the excitation of respiratory center reflexly and evokes the inspiratory effect. However, in view of the muscle activities the apnoea elicited by the pressure which may inhibit vital function suggest, contrary to Takagi's theory, the maintenance of excitatory state rather than the inhibition of the central activity. Moreover, the phenomena described under the name of "respiratory inhibitory reflex" by Lutz might be regarded as the apneusis caused by the continued excitation of the center, though it appears at all to be inhibitory from the point of view of breathing movement.

The thesis that the above-mentioned rapid respiratory reflex is elicited as the results of two or more successive excitation of the center quickly is also fortified by the experiments demonstrated by Adrian et al, who recorded the two or more waves in rapid succession followed by a long pause, seems to correspond to clearing motion, from the isolated brain stem of goldfish.

The author's many and hearty thanks are due to Prof. N. Y. Kawamoto for his helpful criticism and advices, and especially to Mr. Y. Maegawa and Mr. K. Yamazaki for their much useful discussion.

Summary

1. The respiratory reflex to touch stimulus was studied on unanaesthetized fish, *Carassius auratus* (L.), by means of recording of electromyogram of the muscle located on the gill region.

2. The application or removal of stimulus may caused the excitation of respiratory center reflexly and then in consequence with it the clearing motion type of breathing followed by an apneusis.

3. The clearing motion type of breathing is due to the occurrence of two or more successive inspiration and expiration rapidly. During the apnoea, usually apneusis, excitation of respiratory center is maintained.

4. Alternation of respiration was discussed from the view point of the central activity.

Literatures

ADARIAN, E. D. and BUTENDIJK, F. J., 1931. J. Physiol. **138**, 104.
BAGLIONI, S., 1907. Zeitschr. f. Allg. Physiol. **7**, 177.
BASUGI, A., 1919. Kyoto Igaku Zassi, **17**, 1266. (in Japanese)
BLACK, E. C., 1951. Univ. Toronto Biol. Series, No. 59, 91.
FUKUHARA, T. and OKADA, H., 1956. J. Physiol. Soc. Jap., **18**, 249 (in Japanese).
KONISHI, J. 1957. Rep. Fish. Mie Univ., **2**, 347.
LUTZ, B. R., 1930. Biol. Bull., LIX (2), 170.
———, 1930. Biol. Bull., LIX (2), 179.
POWERS, E. B. and CLARK, R. T., 1942. Amer. J. Physiol. **138**, 104.
SAKAMOTO, S., 1922. Kyoto Igaku Zassi, **20**, 141. (in Japanese)
SATO, K., 1954. J. Physiol. Soc. Jap. **16**, 597. (in Japanese)
———, 1954. J. Physiol. Soc. Jap. **17**, 46. (in Japanese)
STELLA, G., 1939. J. Physiol. **93**, 263, **95**, 365.
TAKAGI, K., 1952. Brain and Nerve. **4**, 201. (in Japanese)
YOSHIDA, T., 1919. Kyoto Igaku Zassi., **17**, 1327. (in Japanese)

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Copepods Parasitic on Japanese Fishes

13. Parasitic Copepods collected off Kesennuma, Miyagi Prefecture

(*With 6 Text-figures*)

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Faculty of Fisheries, Prefectural University of Mie

The collection here dealt with was made by Prof. S. TACHINO of our Faculty and his collaborators, Mr. K. MORINAGA and Mr. A. MACHII during the summer of 1954, while they were making the biochemical investigation of fish liver at Kesennuma, Miyagi Prefecture. It was obtained from the fishes brought by fishing boats from the Western Pacific to the market at that town for sale. The material preserved in excellent condition comprises numerous specimens which can be classified into nine species. Three of these are of a great value, for they afford each a new record from our waters. They are described in the following in some detail, others being restricted to naming the host species and the region of the body to which the parasite attaches.

Before going into description, I wish to express my most sincere thanks to Prof. S. TACHINO, Mr. K. MORINAGA, and Mr. A. MACHII, for their kindness in sparing the precious time for collection.

Lepeophtheirus nordmanni (MILNE-EDWARDS), 1840

(Figs. 1 and 2)

Caligus nordmanni, MILNE-EDWARDS 1840, p. 455.
Lepeophtheirus nordmanni, BAIRD 1850 (after WILSON); HELLER 1865, pp. 180–183, pl. 16, figs. 1–2; RATHBUN 1884, p. 487; THOMPSON 1895, p. 118, pl. 27, fig. 5, a; SCOTT, T. 1900, p. 151, pl. 5, figs. 32–37; GRAEFFE 1902, p. 12; WILSON 1905, pp. 623–625, pl. 19; 1932, p. 411, fig. 258; BRIAN 1906, p. 47, pl. 1, fig. 1; SCOTT, T. and A. 1913, pp. 66-67, pl. 12, fig. 1, pl. 16, figs. 4-11; SCOTT, A. 1928, p. 93; HEEGAARD 1943, p. 20; DELAMARE-DEBOUTTEVILLE and NUNES-RUIVO 1954, p. 201.
Lepeophtheirus hippoglossi, BRIAN 1898, p. 210, pl. 1, fig. 4, pl. 2, fig. 13; 1899, p. 199.
(As to further bibliography see BRIAN 1906).

Distribution: Mediterranean (MILNE-EDWARDS[9], HELLER[6], BRIAN[2], HEEGAARD[5], DELAMARE-DEBOUTTEVILLE and NUNES-RUIVO[3]), Adriatic (GRAEFFE[4]), Irish Sea (THOMPSON[17]), English seas (T. SCOTT[12]), Atlantic coast of N. America (RATHBUN[10], WILSON[19,20]), Californian coast (WILSON[20]). On *Mola mola*.

Specimens examined: 26 females, no male, on the head of *Mola mola* (LINNÉ), August 3, 1954.

Fig. 1. *Lepeophtheirus nordmanni* (M.-Edwards), female.

A, dorsal view; B, 1st antenna, ventral view; C, 2nd antenna, mouth tube, 1st and 2nd maxillae in situ; D, 1st maxilliped; E, terminal part of same, further enlarged; F, 2nd maxilliped; G, sternal furca; H, caudo-lateral region of genital segment, showing 5th and 6th legs; I, caudal ramus. A×9, B, E, I×47, C, G×30, D, F ×24, H ×37.

Female: Body 11.5 mm. long, 6.20 mm. wide, egg strings 10.04 mm. long; color in alcohol pale yellowish, with brownish surface ribs and appendages, pigment patterns hardly discernible, egg strings pale yellowish brown.

Body flattened. Carapace circular, longer than half of entire length, as long as its own width. Frontal plates very short and narrow, half as wide as carapace. Longitudinal ribs nearly parallel forward, but curving backward like parentheses. Transverse rib arched anteriorly and at about posterior one third of carapace. Eyes situated at anterior one third and connected with each of longitudinal ribs by coupling of short ribs. A pair of longitudinal grooves run from the bases of frontal plates as far near as eyes. Lateral areas slightly narrower than central area, narrowing backward and not extending beyond postero-median lobe, which is truncate posteriorly and measures one third of entire width. Paired sinuses small, ovate. Marginal flanges moderately broad. Fourth thoracic segment two ninths as wide as carapace, shorter than wide, and with cuneiform sides, narrowing both in front and in the rear. Genital segment longer than wide, about two fifths as long as carapace on midline, with gracefully curved anterior shoulders and linguiform posterior lobes, which extend for a short distance backward on either side of abdomen. The latter fusiform, moderately large in size and about four fifths as long as preceding segment. Lines of border between those consecutive segments indistinct.

First antennae have basal joint triangular and fringed with short plumose spines along anterior border; apical joint rod-shaped, bearing the terminal bundle of simple spines and a rudimentary one on posterior side about the middle. Second antennae have 1st joint armed with short blunt, posterior process; 3rd joint unusually long and slender, with sharp, curved apex and carrying 2 tiny spines, one at the base and the other a short distance distally. First maxillae slender, falciform, blunt at tip and with 2 basal tubercles wearing a few minute hairs, which are associated with a similar tubercle on the sternum just behind. Second maxillae deeply bifurcate, with blades narrow and somewhat divergent; tubercle just in front of their bases bearing 2 unequal spines. Distal joint of 1st maxillipeds longer than proximal joint, terminating in 2 unequal, relatively short claws fringed by fine hairs, and carrying a linguiform lobe a short distance proximally. Second maxillipeds powerful, but with uncommonly slender palm; claw sharp, well-curved like a sickle, reaching the base of palm, and with a short accessory spine behind the center. Sternal furca Y-shaped; diverging arms of the Y rugose and combined together by oblong ovate base. Furca accompanies on either side a short triangular spine of sternum.

First legs provided with a claviform rudiment of endopod, which is tipped by 2 vestigial spines. Protopodite of 2nd legs 2-jointed and the 2 rami 3-jointed; 1st exopodite joint elongate and 1st and 2nd endopodite joints with a lunular

expansion on outer side. Third legs with exopodite 3-jointed whereas endopodite 2-jointed; margin of protopodite between the rami expanded in a hairy, semi-circular lobe. Fourth legs 4-jointed, geniculation intervening between first 2 joints. Fifth legs are represented each by a very short plumose spine surmounting on a small papilla which is present on the ventral surface of genital segment at the posterior end of its lateral lobe. Sixth legs locate internally to the preceding and are triangular lobes fringed by 3 short plumose spines on outer margin.

Disposition of spines and hairs on the first 4 pairs of legs is indicated in the following diagram:*

Leg	Margin	Sternal plate	Protopodite		Exopodite			Endopodite		
			I	II	I	II	III	I	II	III
I	outer			1p		3H		2rh		
	inner			1p	c	3P, 1p				
II	outer	f		f, 1p	f, 1H	1H	2H, 1Q	c	c	c
	inner		1P	f, 1rh	c, 1P	c, 1P	c, 5P	1P	c, 2P	c, 6P
III	outer	f	f, 1p		1H′	c, 1h	c, 3h		c	
	inner		1P, f, c		1P	c, 1P, c	c, 4P	1P	c, 6P	
IV	outer				1H	1H	1H, 2H			
	inner									

Terminal spines on 1st legs successively longer from within outward, innermost of them bifurcate and the others with finely pectinate, narrow rim. Of external spines on 3rd exopodite joint of 2nd legs, most basal one has a broad, crescentic, finely striated rim on 2 sides, and the terminal one, being far longer, is hairy on the inside, while rimmed on the outside. Basal claw of exopodite of 3rd legs has apical part strongly elongate in falciform and turning inward at right angles to the shaft. Basal joint of 4th legs without spine; terminal 3 joints with narrow external rim. Spines on the latter joints rimmed and accompanying at their base with a crescentic lamina; inner 2 of apical spines much longer than the rest and serrated along their borders. Caudal rami small in size, bearing a short plumose spine on either side of 3 ordinary terminal spines, and with setose inner border.

Remarks: Except a record from California, the present species has been confined to the Atlantic and the Mediterranean. So far as I am aware, this is

* Abbreviations used in the table: c, row of downy hairs; f, marginal flange; H, stout spine; h, feeble spine; H′ hook-like claw; P, long plumose spine; p, short plumose spine; Q, spine plumose on one side, rimmed on the other; rh, rudimentary spine. Roman numerals indicate the numerical orders of joints, or of legs, and Arabian ones the number of spines present on each of them.

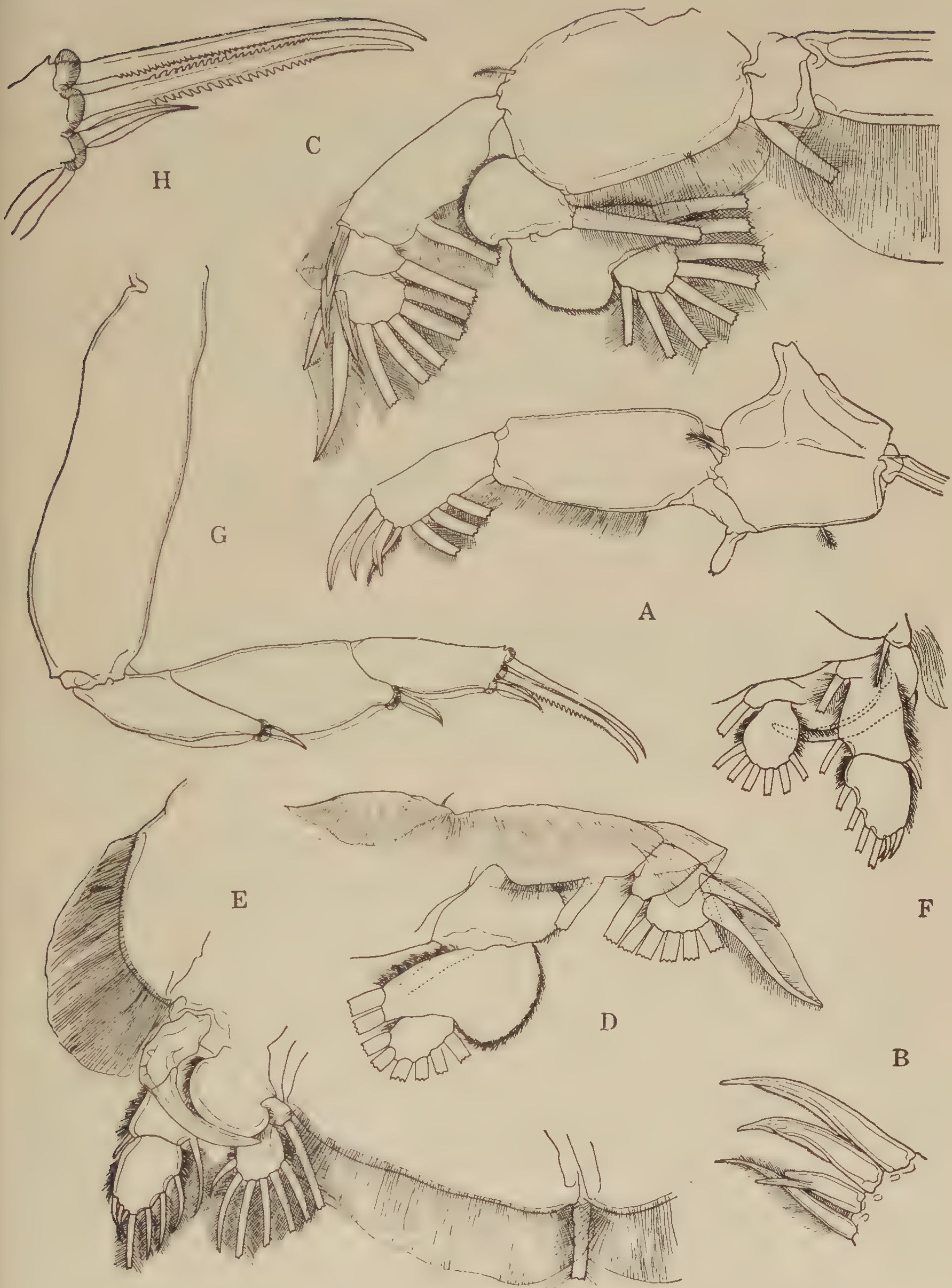

Fig. 2. *Lepeophtheirus nordmanni* (M.-EDWARDS), female.
A, 1st leg; B, terminal spines of same; C, 2nd leg; D, same, posterior surface; E, 3rd leg; F, rami of same, posterior surface; G, 4th leg; H, terminal spines of same. A, C-G ×37, B, H ×74.

the first record of the species from the Western Pacific. Since this parasite is restricted to *Mola mola* which inhabits all around the world, its occurrence from our coast appears quite natural.

Family Euryphoridae

Genus *Gloiopotes* STEENSTRUP and LÜTKEN, 1861

Gloiopotes longicaudatus (MARUKAWA), 1952

As regards synonymy see SHIINO 1954a, p. 273.

Specimens examined; 6 females and 3 males, on *Makaira mitsukurii* (JORDAN and SNYDER) (=*Tetrapturus mitsukurii*), August 1, 2, and 29, on the surface around the anus; 6 females and 1 male, on *Makaira mazara* (JORDAN and SNYDER) (new host), August 19, infected region on the host body unnamed.

Genus *Elytrophora* GERSTAECKER 1853

Elytrophora brachyptera GERSTAECKER, 1853

As to the synonymy see SHIINO 1954a, p. 279.

Specimens examined; 7 females and 7 males, on *Thunnus thynnus* (LINNÉ) (=*Thynnus orientalis*), on the head, August 3; 5 females and 3 males, on the same host, on the gills, August 12 and 17; 1 female, on *Neothunnus albacora* (LOWE) (new host), on the head, August 17; 11 females and 2 males, on *Parathunnus obesus* (LOWE) (=*Thynnus sibi*), on the inner surface of operculum, August 5.

Family Pandaridae

Genus *Echthrogaleus* STEENSTRUP and LÜTKEN, 1816

Echthrogaleus coleoptratus (GUÉRIN), 1817

As to the synonymy see SHIINO 1954b, p. 292.

Specimens examined: 18 females, on *Lamna ditropis* HUBBS and FOLLETT (new host), on dorsal side, August 12; 20 females, on the same host, on pelvic fin, August 17 and 27; 2 females, on *Glyphis glaucus* (LINNÉ) (=*Prionace glauca*), infected region of host body not given, August 2; 1 female, on the same host, on the base of pectoral fin, August 5; 4 females, on the same host, on dorsal side, August 12; 11 females, on the same host, on lower jaw, August 19.

Genus *Pandarus* LEACH, 1816

Pandarus satylus DANA 1852

As to the synonmy see SHIINO 1954b, p. 312.

Specimens examined; 16 females, on *Glyphis glaucus* (LINNÉ), on body side and on pelvic fins, August 1, 2, 17 and 19; 2 females 'on *Isurus glaucus* (MÜLLER

and HENLE), August 2; 1 female, on *Sphyrna zygaena* (LINNÉ), August 3.

Genus *Dinematura* LATREILLE, 1892

Dinematura latifolia STEENSTRUP and LÜTKEN, 1861

As to the synonymy see SHIINO 1954b, p. 308.

Specimens examined: 4 females, on *Lamna ditropis* HUBBS and FOLLETT (new host), on unnamed region, August 12 and 27; 5 females, on *Isurus glaucus* (MÜLLER and HENLE), on belley and on pelvic fins, August 17 and 19.

Dinematura affinis THOMSEN, 1949

(Figs. 3 and 4)

THOMSEN 1949, pp. 14–17, pl. 5, figs. 1–12.

Specimens examined: 8 females, on *Lamna ditropis* HUBBS and FOLLETT, on dorsal, ventral and lateral sides of body and on pelvic fins, August 12 and 27.

Female: Body exclusive of caudal rami 18.36 long, carapace inclusive of lateral lobes 7.09×7.22, 4th segment to abdomen 11.65×5.32, egg string not less than 18.10 (all in mm.); pale yellowish brown in preservative, with dark colored patterns on central part of anterior margin of carapace, and with yellowish egg strings.

Carapace together with first 2 free segments circular in outline, and about as long as wide. Frontal plates narrow, uniform in width and round at lateral ends. Central area longer than wide, rectangular, truncate on posterior margin, and bordered from lateral areas by nearly parallel longitudinal sutures. Lateral areas narrower than half of central area, beyond which they extend backward as linguiform lobes. Inner margin of the lobes strengthened, in anterior half, by a ridge erected over surface. Marginal rims of carapace moderately broad and finely striated. Second (first free) thoracic segment short, with straight posterior border; lateral parts directing obliquely backward, partly concealed beneath carapace and fringed by broad rims on posterior side. Third segment about as long as 2nd, but narrower, with postero-median sinus and short lateral parts, which are more or less irregular in outline and covered from above by marginal rims of preceding segment. Fourth segment two thirds as wide as carapace, carrying a pair of well-developed dorsal plates; anterior border nearly straight but produced on midline in a short narrow neck fitting into the corresponding sinus of preceding segment. Dorsal plates quadrate, only a trifle shorter than segment width and deeply separated from each other, though slightly overlapping. Genital segment enormous, extremely prolonged, one and

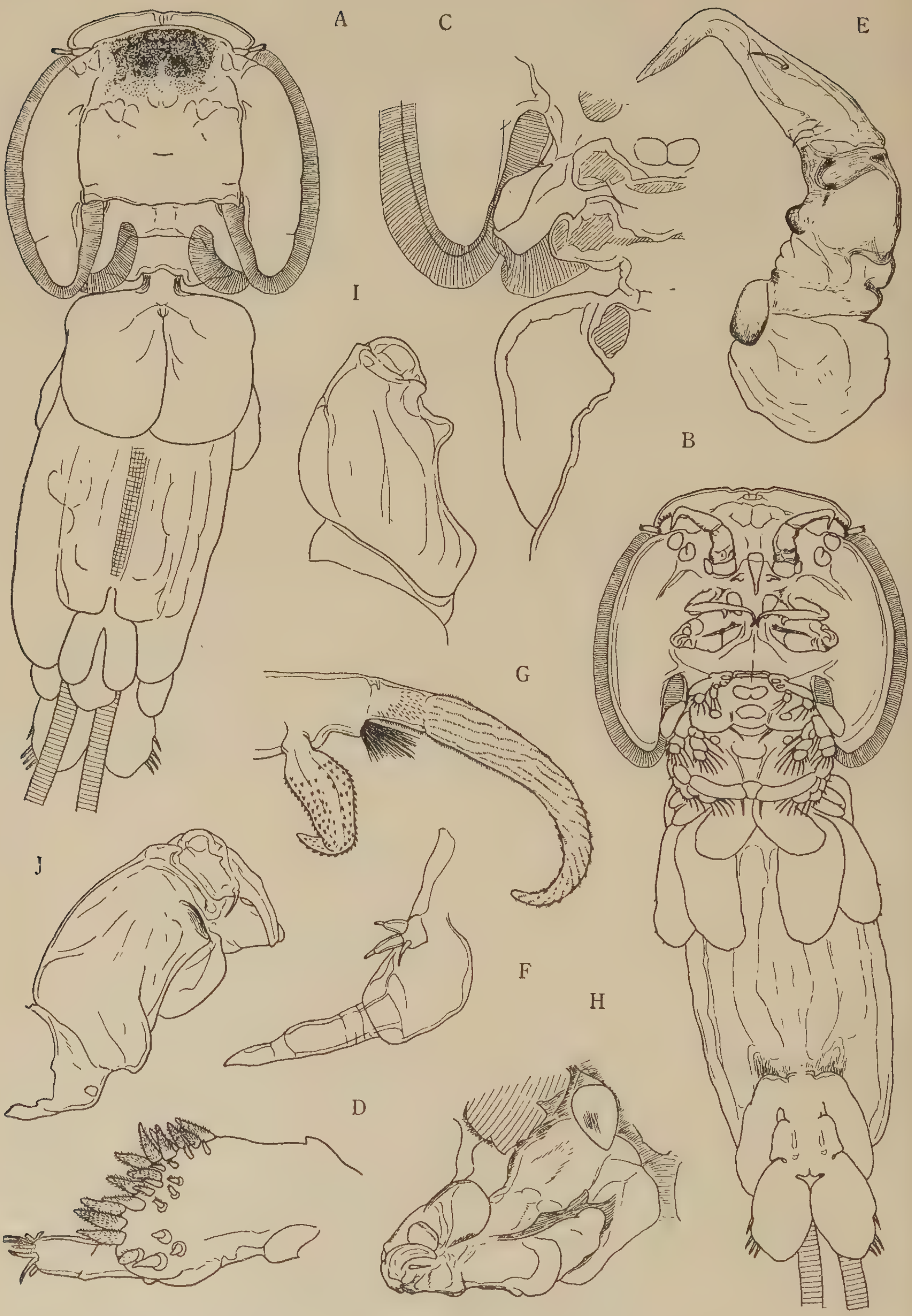

Fig. 3. *Dinematura affinis* THOMSEN, female.

A, dorsal view; B, ventral view; C, postero-lateral part of carapace and lateral parts of 2nd to 4th thoracic segments, with appendages removed, ventral view; D. 1st antenna, ventral view; E, 2nd antenna; F, 2nd maxilla; G, terminal part of 1st maxilliped; H, 2nd maxilliped with triangular sternal pad; I, 2nd maxilliped, anterior view; J, same, posterior view. A,B ×5.3, C ×10, D ×41, E,I,J ×27, F ×83, G ×52, H ×19.

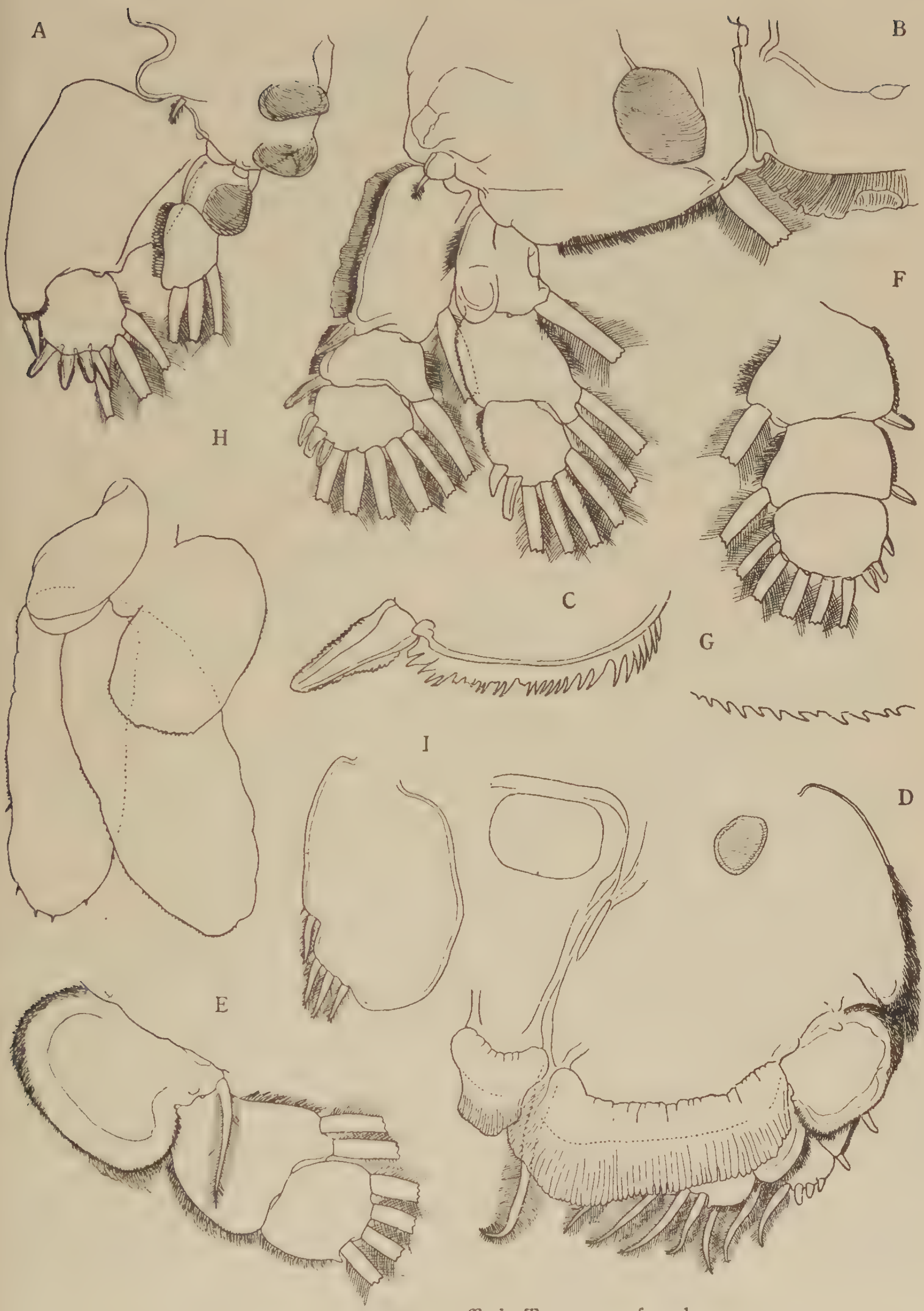

Fig. 4. *Dinematura affinis* THOMSEN, female.

A, 1st leg; B, 2nd leg; C, outer margin of 2nd exopod joint of same, posterior view; D, 3rd leg; E, endopod of same; posterior view; F, exopod of same; G, part of outer margin of 1st exopod joint of same; H, 4th leg; I, caudal ramus. A, B, E, F ×41, C ×150, D ×27, G ×170, H, I ×14.

two fifths as long as carapace, five sevenths as wide, with sides almost parallel, but somewhat converging near fore end, and with bilobed hind end. Sixth segment elongate oval, extremely flattened, inserted between the posterior lobes of previous segment, beyond which it extends a little. It is covered from above by a pair of oblong oval dorsal plates, which are separated by a deep median crevice and not exceeding its posterior end. Abdomen entirely concealed under those plates, small in size, and almost pentagonal. Arrangement of ventral pads on carapace and on succeeding segment is as follows: 2 pairs of oval pads just behind 1st antennae, disposed one behind the other on either side; a triangular pair internal to 1st maxillipeds and just in front of 2nd maxillipeds; another triangular, but larger pair on extreme lateral margins of 2nd thoracic segment; an oval, largely coalesced pair behind 1st legs on midline.

First antennae have distal joint short, indistinctly divided into 2 subjoints and tipped by short spines; proximal joint fringed along anterior border with short but thick, conical, finely ciliated spines, besides with smaller scattering ones on inner face. Second antennae robust, 3-jointed; basal joint with a round, strongly chitinized external pad, succeeding joint uneven on surface and with crescentic external bulge, and terminal joint sharp, curved like a hook and with 2 accessory spines, disposed one close to base and the other about center. Proboscis acuminate. First maxillae transformed into pads. Second maxillae very small in size, placed just outside the base of proboscis and composed of broad basal and 2 styliform apical joints; endite short, surmounted with 2 stouter and 1 feebler spines. First maxillipeds with longer terminal and shorter subterminal claws, both of these with curled apices, but differently dressed with hairs. Greater part of terminal claw covered with oblique rows of tiny hairs, which are interrupted at intervals, while small basal part uniformly hairy and accompanying at the very base a tuft of long stiff hairs. Subterminal claw flattened and invested with short, pointed spinules on its surface. Second maxillipeds attached to sternum by a broad base and directing outward. Their palm has a longitudinal rib on ventral surface, 2 conical bulges on posterior side, disposed one at base and the other near end, and a triangular terminal projection on anterior side as well as a longitudinal ridge of crescent-shape just behind. Claw short, falciform, shutting down against the inner surface of the triangular projection of palm, and with a feeble basal spine. Sternal furca absent.

First legs biramous, having 2-jointed rami; endopodite short, not exceeding enlarged proximal joint of exopodite; protopodite with 2 oval, corrugated bosses and 1st joint of endopodite with similar one, all placed along inner margin of joints. Protopodite of 2nd legs expanded and with a large corrugated boss near sternal plate; both rami composed of 3 joints, of which 1st joint of exopodite is

much longer than others and the same of endopodite has an oval, smooth boss at outer distal angle. Third legs provided with a small corrugated boss close to each antero-lateral angle of basal apron; 2 rami 3-jointed, inner ramus exceeding the outer in size. Fourth legs much larger than preceding ones and different in structure, showing fleshy appearance. Protopodite expanded both outward and inward in oval lobes; outer lobe folded and inner lobe fringed with fine serration on posterior margin as well as partly on inner margin. Two rami foliaceous, elongate oval and unjointed; exopodite slightly shorter and narrower than endopodite, with a few marginal spinules and partly as well as insensibly serrated on outer margin; endopodite also serrated on this margin. Fifth legs absent. Sixth legs represented by a pair of narrow, posteriorly directed lobes, apices of which extend beyond lateral lobes of genital segment. Disposition of spines and others on first 3 pairs of legs is indicated in the following diagram.**

Leg	Margin	Sternal plate	Protopodite	Exopodite			Endopodite		
				I	II	III	I	II	III
I	outer		1p	1H	C, 4H		1B	C	
	inner		2B, 1p	c	c, 3P			3P	
II	outer	f	1p	f, C, 1H	C, 1H	C, 3H	c, 1B′	c	C, 2H
	inner		1P, c	c, 1P	c, 1P	C, 5P	1P	c, 2P	c, 4P
III	outer	f	c, B	C, 1H	C, 1H	3H	c	c	c, 1rh
	inner		f, 1P	c, 1P	c, 1P	c, 5P	1P	c, 2P	c, 4P

Non-plumose spines on swimming legs are furnished with more or less finely serrated rims along 2 borders. Marginal flanges on basal apron of 3rd legs rather thick, showing fleshy appearance. Caudal rami ovate, provided with 4 rather short plumose spines which are displaced to the outer side of the rami; outermost of them slightly apart from the rest.

Remarks: The present material is in complete agreement with *affinis* found from Uruguay a few years ago. Although the original specimens were parasitic on *Cetorhinus maximus* Gunner which occurs also in Japan, present ones were obtained from another shark. So far as I am conscious, this is the second record of this species from the world and the first occurrence from the Pacific.

** Abbreviations other than those indicated in the following are as in the previous table. B, corrugated boss; B′, smooth boss; C, row of tiny spinules.

Family Anthosomidae
Genus *Anthosoma* LEACH, 1816
Anthosoma crassum (ABILDGAARD), 1794

As regards the synonymy see SHIINO 1955, p. 50.

Specimens examined: 5 females, on *Lamna ditriops* HUBBS and FOLLETT, August 27; infected region on host body unnamed.

Family Eudactylinidae
Genus *Krφyeria* VAN BENEDEN, 1853
Krφyeria carchariae-glauci HESSE, 1879

(Figs. 5 and 6)

Krφyeria carchariae-glauci, HESSE 1879, pp. 20–23, pl. 21, figs. 1–15; WILSON 1922, p. 55; DELAMARE-DEBOUTTEVILLE and NUNES-RUIVO 1954, pp. 205–210, figs. 4–5.
K. gracilis, WILSON 1932, pp. 453–454, pl. 29; 1935, p. 340.

Distribution and Hosts: English channel (HESSE[7]), Mediterranean (DELMARE-DEBOUTTEVILLE and NUNES-RUIVO[3]), Woods Hole, Gulf of Mexico (WILSON[19,20]). On *Carcharinus glaucus* [HESSE, DELAMARE-DEBOUTTEVILLE and NUNES-RUIVO], *C. milberi*, *Galeus glaucus*, *Scoliodon terrae-novae* [WILSON].

Specimens examined: 3 females, on the gills of *Glyphis glaucus* (LINNÉ), August 11.

Female: Elongate, slender; total length 7.90, carapace 1.02×1.32, 2nd to 4th thoracic segments 0.93×0.66, genital segment 5.10×0.79, abdomen 0.85×0.32 (all in mm.); anterior region of body and abdomen whitish, while genital segment pale brownish purple in alcohol.

Carapace wider than long, triangular, having lateral lobes expanded like a pair of wings. Front truncate, lateral lobes well round, but somewhat acuminate backward, and hind border nearly straight. Dorsal surface with Y-shaped rib. A pair of stout acicula arise from the bottom of shallow lateral sinuses and extend backward as well as somewhat dorsally to reach 4th thoracic segment. Second to 4th (1st free to 3rd) segments only slightly shorter than carapace in their combined length and subequal to one another. Second segment as wide as hind border of carapace and following ones successively but only slightly narrower. Genital segment elongate cylindrical, occupying two thirds of entire length, winder than preceding segments, almost uniform in width except for anterior contraction, and with parallel longitudinal striations. Abdomen very slender, about as long as 2nd to 4th segments put together and composed of 3 segments which are decreasing in length as well as in width from before backward.

First antennae filiform, 6-jointed, basal joint the longest, 3rd coming next

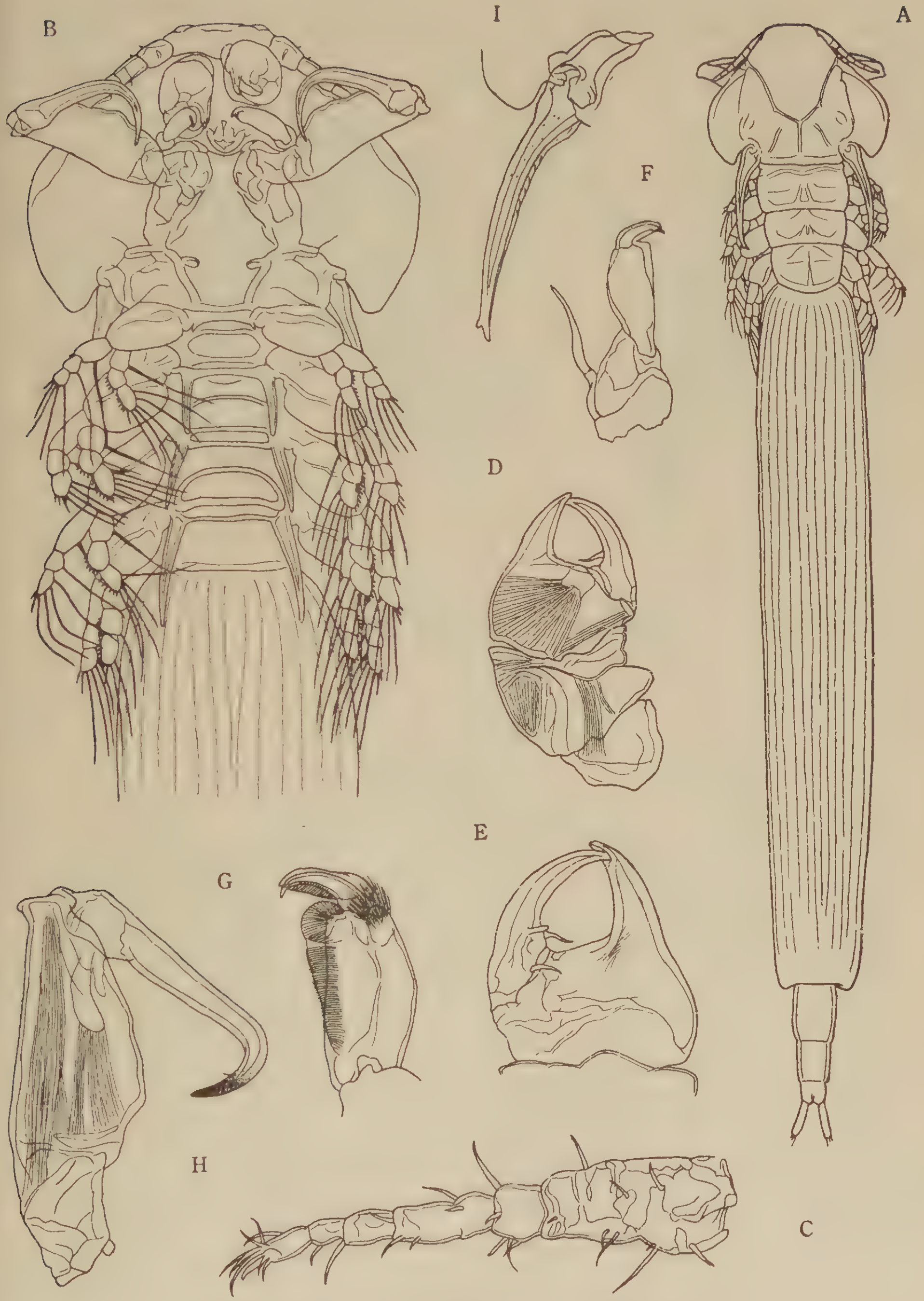

Fig. 5. *Krφyeria carchariae-glauci* HESSE, female.

A, dorsal view; B, anterior region of body, ventral view; C, 1st antenna; D, 2nd antenna; E, same, posterior face 1st; F, maxilliped; G, tip of same; H, 2nd maxilliped I, aciculum of carapace. A ×19, B ×41, C, E ×120, D, F, H ×83, G ×170, I ×52.

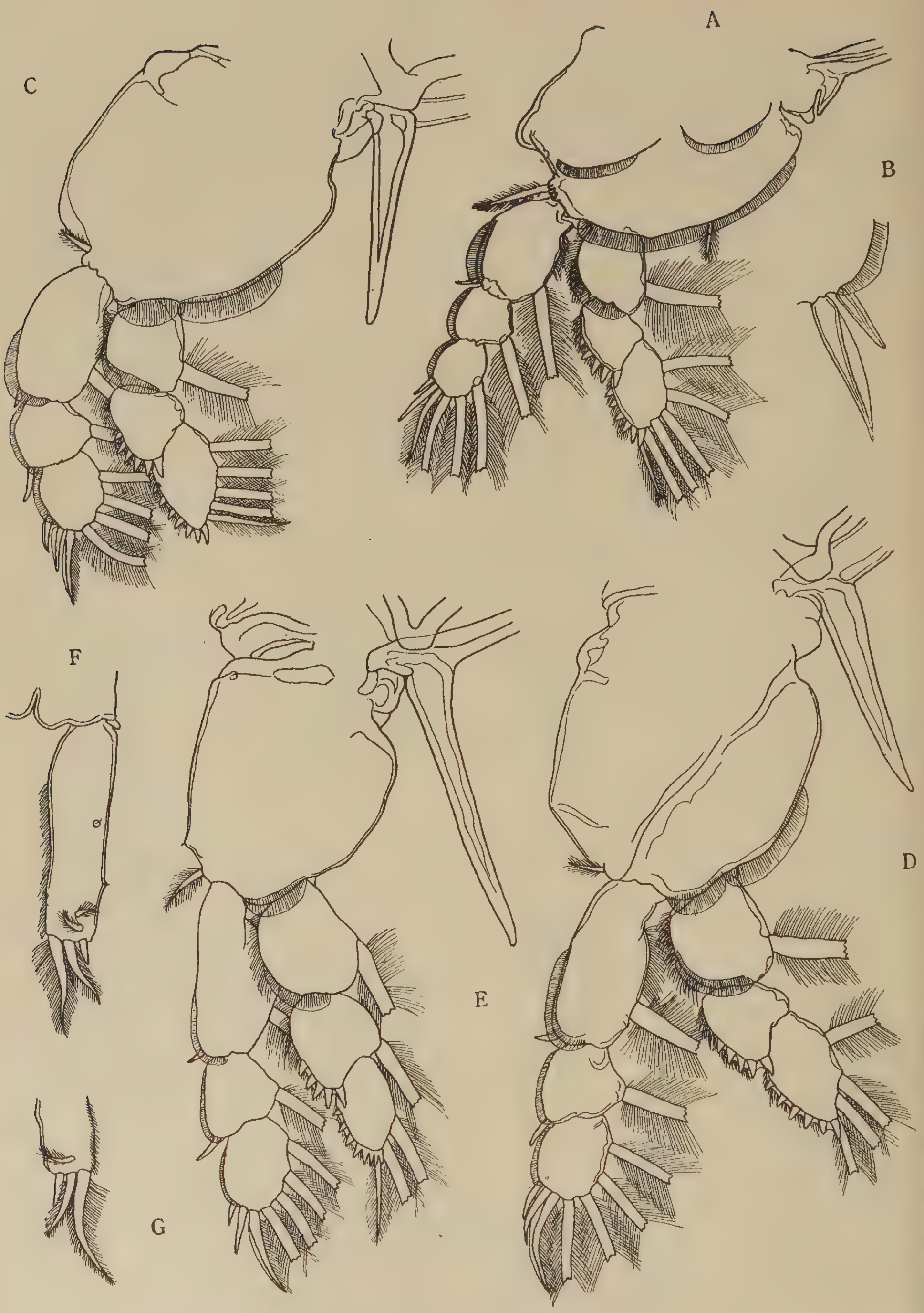

Fig. 6. *Krφyeria carchariae-glauci* HESSE, female.

A, 1st leg; B, external spines on 3rd exopod joint of same; C, 2nd leg; D, 3rd leg; E, 4th leg; F, caudal ramus, ventral view; G, tip of same, dorsal view. A, C–G ×120, B ×340.

and the rest much shorter and subequal; each joint with a number of setae and apical joint bearing terminal bunch of them. Second antennae composed of 4 joints, terminal 2 of which make a chela exactly imitating that of a crab. Palm of the chela produced into an elongate, acuminate process on inner side; claw falciform, shutting down against that process and with 2 short spines as well as blunt, spiniform papilla close to the base. Basal 2 joints rather short and broad. First maxillipeds much smaller than other limbs in size. Basal joint short, with an outer flagellum; 2nd joint quadrate, fringed by bread inner rim ornamented with fine parallel streaks and with a bunch of stiff hairs at outer distal angle; terminal claw falciform, movably articulated and with striated inner rim. Second maxillipeds powerful, prehensile and protruding beyond lateral margin of carapace; palm narrowly triangular, tapering distally and more or less irregular on inner border; terminal claw sharp, strongly chitinized, well curved like a hook and reaching near the base of plam.

Four pairs of legs similar in structure and in size, biramous, having 3-jointed rami; their protopodite expanded and united with corresponding one of other side through a median sternal plate. Each of the legs has at the junction of protopodite with sternal plate a long stout stylet except in 1st pair where this is reduced to a tiny pointed process.

Disposition of spines and other armatures in 4 pairs of legs is tabulated in the following:***

Legs	Border	Protopodite	Exopodite			Endopodite		
			I	II	III	I	II	III
I	outer	1p, C	f, 1h	f	f, 2h	f, c	c, hh	c, hh
	inner	f, 2f, 1p	c, 1P	1P	3P, 1p	1P		5P, 1p
II	outer	1p	f, 1h	f, 1h	f, 2h	f, c	c, hh	c, hh
	inner	2f	c, 1P	1P	4P, 1q	1P		4P, 1p
III	outer	1p	f, 1h	f, 1h	f, 2h	f, c	c, hh	c, hh
	inner	2f	c, 1P	1P	4P, 1q	1P		4P
IV	outer	1p	f, 1h	f, 1h	f, 2h	f, c	c, hh	c, hh
	inner	f	c, 1P	1P	4P, 1q	1P	1P	2P, 1p

Non-plumose spines on the legs with narrow rim at least on one side. Short spines arranged in line on outer border of endopodite are united by membrane between adjoining ones. First legs furnished on the surface of protopodite with 2 additional structures resembling marginal rim. Caudal rami very narrow, having almost parallel sides, fringed by a row of hairs along inner

*** Abbreviations other than indicated in the following are as before. hh, row of short spines, q, short spine plumose on one side, rimmed on the other.

margin and terminating in 2 short plumose spines and a much shorter non-plumose one. They bear, in addition, 3 short subterminal plumose spines, placed 1 on dorsal and 2 on ventral surfaces.

Remarks: In spite of Hesse's inadequate illustrations, a revision of the species was successfully carried out by Delamare-Deboutteville and Nunes-Ruivo[3], who made Wilson's *gracilis*[26] its synonym. Having hitherto been restricted to the Mediterranean and the Atlantic, this species is recorded for the first time from the Pacific. The genus *Krφyeria* is new to Japan also.

References

1. van Beneden, P. J., 1853. Notice sur un genre nouveau de la tribu des caligiens (genre Kröyeria, van Ben.). Bull. Acad. Roy. Belg., Vol. 20, pp. 23–30, Pl. 1.
2. Brian, A., 1906. Copepodi parassiti dei pesci d'Italia, pp. 1–187, Pls. 1–21, Genova.
3. Delamare-Deboutteville, C. and Nunes-Ruivo, L. P., 1954. Copépodes parasites des poissons Méditerranéens (3° ser.). Vie et Milieu, Vol. 4, pp. 201–218.
4. Graeffe, E., 1902. Übersicht der Fauna des Golfes von Triest nebst Notizen über Vorkommen, Lebensweise, Erscheinungs- und Laichzeit der einzelnen Arten. Arb. Zool. Inst. Wien, Vol. 13, pp. 1–17.
5. Heegaard, P. E., 1943. Parasitic copepods mainly from tropical and antarctic seas. Ark. f. Zool., Vol. 34 A, No. 18, pp. 1–37.
6. Heller, C., 1865. Crustaceen. Reise der Österreichischen Fregatte Novara um die Erde, Zool. Teil, Vol. 2, Pt. 3, pp. 1–289, Pls. 1–25, Wien.
7. Hesse, E., 1879. Description des crustacés rares ou nouveaux des côtés de France, 29° art. Ann. Sci. Nat., (6) Vol. 8, No. 11, pp. 1–34, Pls. 19–21.
8. Leigh-Sharpe, W. H., 1933. A list of British fishes with their characteristic parasitic Copepoda. Parasitol., Vol. 25, pp. 109–112.
9. Milne-Edwards, H., 1840. Histoire naturelle des crustacés, pp. 432–529, Pls. 38–41.
10. Rathbun, R., 1884. Annotated list of the described species of parasitic Copepoda (Siphonostoma) from American waters contained in the United States National Museum. Proc. U. S. Nat. Mus., Vol. 7, pp. 483–492.
11. Scott, A., 1928. The copepod parasites of Irish sea fish. Rep. Lancashire Sea Fish. Lab., 1928, pp. 81–118, Pl. 1.
12. Scott, T., 1900. Notes on some crustacean parasites of fishes. 18th Ann. Rep. Fish. Board Scotl , 1900, pp. 144–188, Pls. 5–8.
13. ——— and Scott A., 1913. The British parasitic Copepoda, 2 Vols., pp. i–x, 1–252, Pls. A, B, 1–72, London.
14. Shiino, S. M., 1954a. Copepods parasitic on Japanese Fishes, 4. The family Euryphoridae. Rep. Fac. Fish., Pref. Univ. Mie, Vol. 1, No. 3, pp. 273–290.
15. ———, 1954b. Copepods parasitic on Japanese Fishes, 5. Five species of the family Pandaridae. Ibid., Vol. 1, No. 3, pp. 291–332.
16. ———, 1955. Copepods parasitic on Japanese Fishes, 8. The Anthosomidae. Ibid., Vol. 2, No. 1, pp. 50–69.
17. Thompson, C., 1893. Revised report on the Copepoda of Liverpool Bay. Trans. Liverpool Biol. Soc., Vol. 7, pp. 175–230, Pls. 15–35.
18. Thomsen, R., 1949. Copépodos parásitos de los peces marinos del Uruguay. Comm. Zool. Mus. Hist. Nat. Montevideo, Vol. 3, No. 54, pp. 1–41, Pls. 1–14.

19. WILSON, C. B., 1905. North American parasitic copepods belonging to the family Caligidae. Pt. 1, the Caliginae. Proc. U. S. Nat. Mus., Vol. 28, pp. 479–672, Pls. 5–29.

20. ——, 1932. The copepods of the Woods Hole region Massachusetts. U. S. Nat. Mus. Bull. 158, pp. I–XIX, 1–635, Pls. 1–41.

21. ——, 1935. Parasitic copepods from the Dry Tortugas. Pap. Tortugas Lab., Vol. 29, pp. 329–347, Pls. 1–6.

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Copepods Parasitic on Japanese Fishes

14. Three Species from *Spheroides alboplumbeus* (RICHARDSON)

(*With 7 Text-figures and Table 1*)

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The present article deals with three copepods found in the buccal and branchial cavities of a globe-fish, *Spheroides alboplumbeus* (RICHARDSON), taken by myself at Seto, Wakayama Prefecture, June 14, 1954. The collection made from eight individuals of host disclosed an interesting fact that each of them was infected not only by several parasites of the same species, but also by two or three species at the same time. Those species were all different in their systematic position, belonging to the Taeniacanthidae, Chondracanthidae, and Lernaeopodidae respectively.

The taeniacanthid and lernaeopodid from *S. alboplumbeus* are identical with those already recorded by YAMAGUTI (1936, '39) from other species of globe-fishes. Here, a new specific name is proposed for the former, since it appears to me that his assignment is inadequate. The latter is recorded for the first time from the host other than the original one (*S. rubripes*). The chondracanthid is new to science and is made the type of a new genus, for it shows some characters unknown to any genera of the family.

Family Taeniacanthidae

Genus *Irodes* WILSON, 1911

Irodes yamagutii n. sp.

(Figs. 1–3)

Irodes tetraodontis, YAMAGUTI 1939, pp. 4–5, pls. 3–4, figs. 30–45; GUSSEV 1951, p. 397, fig. 2.
nec *Bomolochus tetradonis*, BASSETT-SMITH 1898, p. 4, pl. 1, fig. 2.
nec *Irodes tetrodontis*, WILSON 1911, p. 390.

Material: 43 females and 15 males obtained from all 8 individuals of host.

Habitat: On inner surface of operculum and floor of gill cavity. The parasite swallows up the host skin in the ventral depression of carapace, bringing about a mammiform tumor on the skin, and thus holds the body securely together with the aid of mouth parts.

Female: Body somewhat stumpy, broad in front, tapering backward; length 2.15, carapace 0.53×1.07, 2nd thoracic segment 0.48×1.05, 3rd 0.28×0.90,

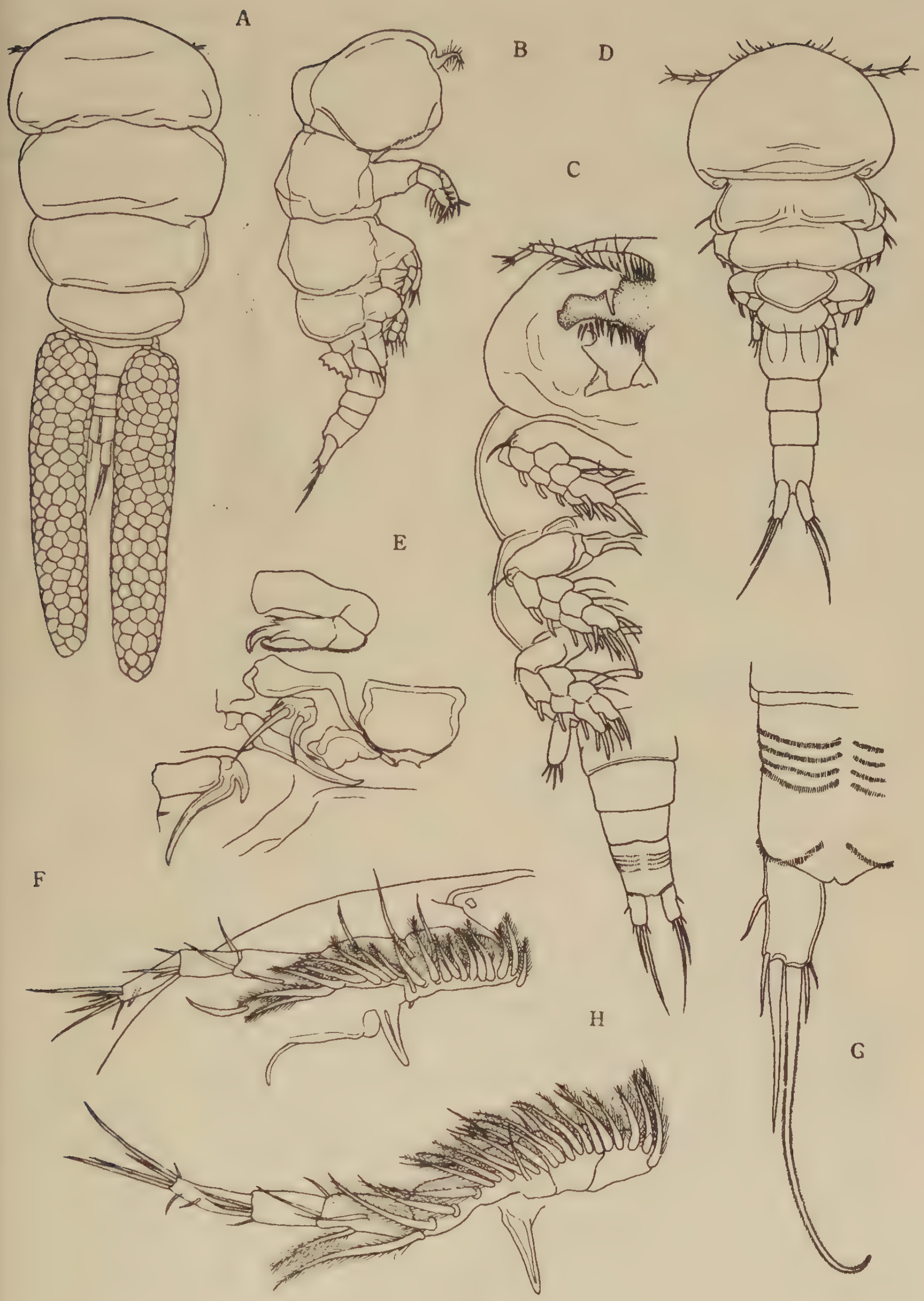

Fig. 1. *Irodes yamagutii* n. sp.

A–C, female; A, dorsal view; B, lateral view; C, ventral view; D, male, dorsal view; E–G, female; E, 2nd antenna and mouth parts in situ; F, 1st antenna and 1st maxilla; G, last segment with caudal ramus, ventral view; H, male, 1st antenna and 1st maxilla. A, B ×26.5, C ×47, D ×41, E–G ×120, H ×170.

4th 0.25×0.68, 5th 0.08×0.38, genital segment 0.15×0.37, abdomen 0.55 long, 1st segment 0.16×0.28, 2nd 0.14×0.24, 3rd 0.08×0.20, 4th 0.16×0.17 and egg tube 1.68 long (all in mm.). Color yellowish white, with pale yellow egg tubes.

Carapace 3/4 as wide as long, widely round in front, truncate behind and strongly convex dorsally. Its dorsal surface curves around the sides to continue directly to the ventral surface, which becomes deeply depressed in the central region so as to contain oral parts at the bottom. First thoracic segment completely fused with head, partaking in the formation of carapace. Succeeding segments free, regularly decreasing in length and width from the 2nd, which is subequal to the carapace, toward the 4th which is 1/3 as long and 2/3 as wide as the latter. Each of them convex dorsally, flattened ventrally, round on sides and delimited in front and back by straight borders. Fifth segment abruptly narrowed, being reduced to about half the width of 4th, and concealed for the greater part beneath preceding segment, with a small posterior part alone visible from above. Genital segment longer than 5th, but slightly narrower, cylindrical and resembling abdominal ones in appearance. Abdomen a quarter as long as entire body, cylindrical and somewhat tapering caudad. It consists of 4 rectangular segments diminishing in size from before backward except the last which is as long as the 1st. Last segment V-shaped posteriorly, traversed on ventral surface in anterior region by 4 parallel rows of tiny hairs, all interrupted on the midline, and fringed by similar row on caudal margin on each side.

First antennae attached to the edge of ventrally curved front, with both peduncle and flagellum composed of 3 joints, and not extending beyond the sides of carapace. Third joint of peduncle as long as first 2 combined together and all of them thickly fringed along posterior margin with forwardly directing plumose spines. Second joint carries, in addition, 2 feeble simple spines in front of the row of plumose ones and another spine behind; 3rd joint bears an anterior spine. Flagellum as long as peduncle, joints subequal in length and armed with terminal and subterminal spines, all simple. A stout acicular process, which represents dislocated 1st maxilla, is present on the ventral edge of front just behind 1st antenna on each side. Remaining cephalic appendages placed at the bottom of ventral depression of carapace. Second antennae 3-jointed, with apex folded back, geniculation intervening between first 2 joints. First joint longest of all, unarmed. Second joint shortest and carrying a crescentic lobe fringed with minute spinules on distal half of posterior margin. Third joint armed with 2 stouter, curved spines and 3 feebler, almost straight ones at apex, with another stout, solitary one some distance behind and with ensiform, acuminating lobe on posterior side of these; posterior border of joint spinulose extending as far as the tip of that blade. Labrum round on margin, but shallowly notched on the midline and fringed by tiny spinules. Mandibles slender, curved in an obtuse

angle at about the middle and tipped by short sharp, claw-like cutting blade; gnathobasis absent. Second maxillae divided into 2 portions, arranged side by side. Outer portion a quadrangular protuberance and surmounted with 3 simple spines graded in length, the central one longest and the outer one shortest. Inner portion irregular in shape and produced inward into a short triangular lobe. First maxillipeds 2-jointed, composed of short basal and prolonged apical joints; the latter lanceolate, acuminating to the end, and reinforced by a short spine about the center and fine pectination distally to this on both borders. Second maxillipeds 2-jointed and situated behind 1st maxillipeds. First joint in the form of simple rod directing toward the median. Second joint is folded back against

Fig. 2. *Irodes yamagutii* n. sp.

A–G, female; A, 2nd antenna; B, mandible, 2nd maxilla and 1st maxilliped in situ; C, mandible; D, 2nd maxilliped; E, 1st leg; F, same, with rami and spines extended; G, sternal plate between 1st legs, inner face; H–J, male; H, 2nd antenna; I, 2nd maxilliped; J, same, inner face of claw. A, C, D, H, ×340, B, E–G ×170, I, J ×550.

the posterior side of 1st joint, with which it makes an angle of about 30°. It is slender, slightly curved backward away from 1st joint, furnished near its origin on the side facing midventral line with a short blunt, finger-like process, which is directed parallel and tipped by a spine, and with rows of fine spinules along convex margin for some distance back from the tip. There is a short sharp spine just behind 2nd maxillipeds.

First 4 pairs of legs biramous. First pair directed forward unlike others and different in constitution, consisting of broad lamellar protopodite and much smaller, indistinctly 2-jointed rami. Protopodite is triangular, bears on the outside a small oval lobe, which is turned inward and ciliated on margin, and is connected on the inside with its fellow of the opposite side by a conical, apically spinulose sternal plate. Endopodite broad but short, crescentic, exopodite much narrower and both with marginal plumose spines turned backward. Succeeding 3 pairs similar to one another and with rami narrower and longer than those of 1st pair. The rami subequal in size in all pairs and composed of 3 joints, each armed with simple and plumose spines, or with either of these. Protopodite broad, 2-jointed and united across mid-ventral face with corresponding member of the other side by sternal plate, thus forming a continuous basal apron; 2nd joint of protopodite much shorter than 1st and crescentic in shape except in 4th legs, where the 2 joints are coalesced almost completely. Fifth legs very short,

Table 1. Arrangemant of spines and other armatures in 5 pairs of legs of *Irodes yamagutii*

Leg	Border	Sternal plate	Protopodite		Exopodite			Endopodite		
			I	II	I	II	III	I	II	III
I	outer	CC	1p		1P	3p			1p	
	inner		3p			6P		1P	6P	
II	outer	CC	C	1h, C	C, 1H″	C, 1H″	C, 3H″	c, C	C, R	R, 3H′, C
	inner			C, C	1p	1P	4P	1P, C	1P	3P
III	outer	CC	C	1H, C	C, 1H″	C, 1H″	C, 3H″	c	C, R	R, 3H′, C
	inner			C	c	1P	5P	1P	1P	2P
IV	outer	CC	1rh	1h, C	C, 1H″	C, 1H″	C, 3H″	c	c	c, 1rh, 3H′
	inner				c	1P	3P	1P	1P	
V	outer			1h, 2C	C, 4H′	1h, 2C				
	inner				c					

Abbreviations used in the Table 1:—C, row of fine spinules, CC, area covered with fine spinules; c, row of dawny hairs; H, longer simple spine; h, shorter simple spine; H′, non-plumose spine shown in Fig. 3, C; H″, non-plumose spine shown in Fig. 3, D; P, longer plumose spine; p, shorter plumose spine; R, crescentic rim; rh, rudimentary spine. Roman numerals represent the numerical orders of legs, or of joints and Arabian ones the number of spines, or of other armatures present on each of them.

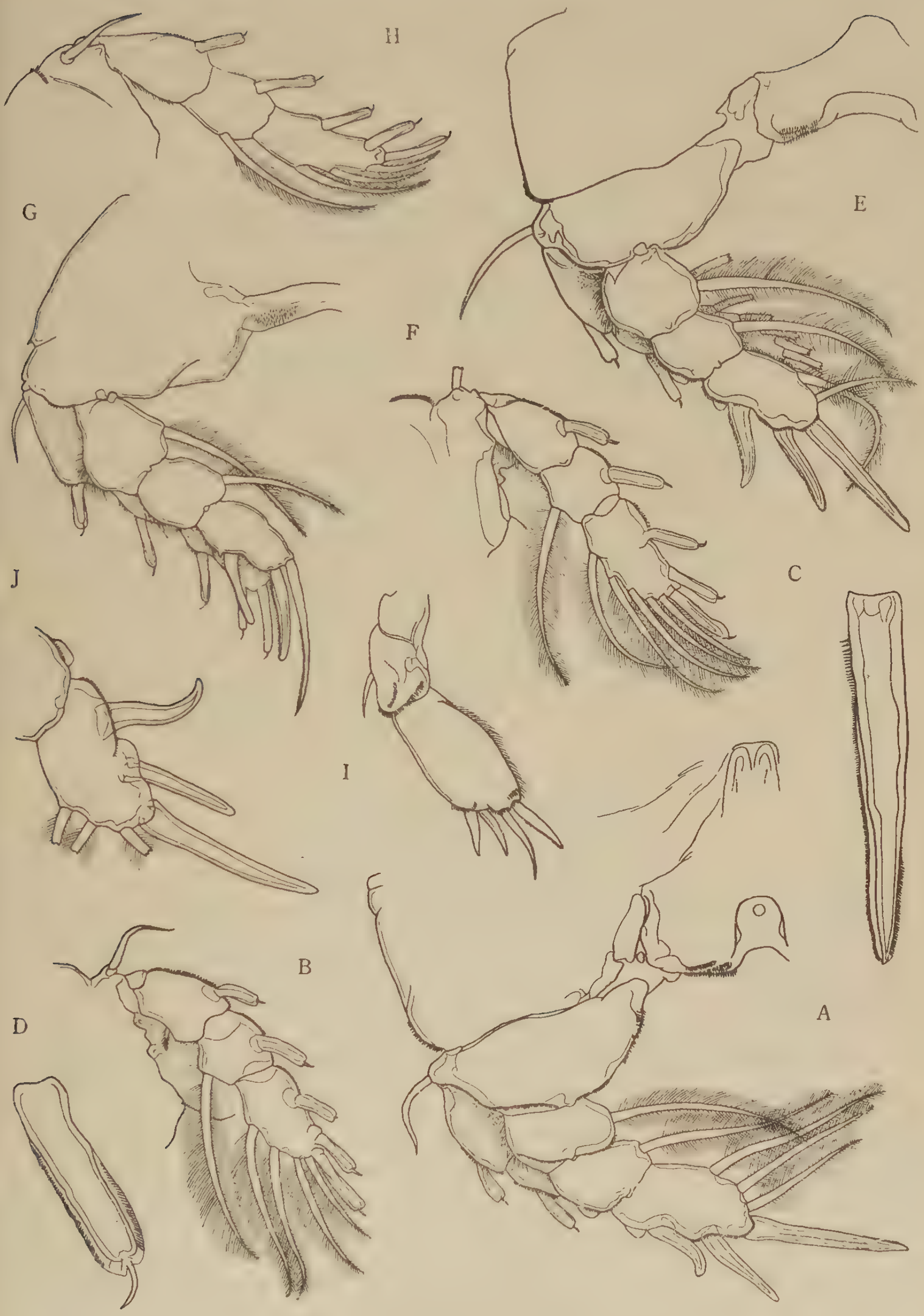

Fig. 3. *Irodes yamagutii* n. sp.

A–I, female; A, 2nd leg, anterior face; B, same, exopodite, posterior face; C, apical spine on endododite of same; D, outer spine on exopodite of same; E, 3rd leg, anterior face; F, exopodite of same, posterior face; G, 4th leg, anterior face; H, exopodite of same, posterior face; I, 5th leg, anterior face; J, male, terminal joint of exopodite of 2nd leg. A, B, E–I ×120, C, D ×485, J ×180.

claviform and attached to lateral side of the segment without forming basal apron. They are uniramous and consist of 2 short narrow basal joints and slightly broader, much longer, flattened oval terminal joint. Armatures on 5 pairs of legs are shown diagrammatically in the Table 1.

Non-plumose spines on the rami of legs are divisible into 2 kinds. One kind of them ends in more or less sharply pointed apex and is fringed on one side with a narrow, finely pectinate rim, but lacking rim on the other side, or retaining, at most, a pectination for a short distance from the tip (Fig. 3, C). The other kind is doubly edged with well-defined pectinate rim and has blunt tip which is prolonged farther into a thin filiform termination (Fig. 3, D). The 1st kind is found on the outer margin of endopodite in 2nd to 4th legs and the 2nd kind on the same margin of exopodite.

Caudal rami shorter than last segment, cylindrical, with truncate end and furnished with 2 unequal terminal spines as well as with 4 tiny hairs, which are disposed 2 at inner distal angle, 1 at outer distal angle and 1 at the center on outer side. Egg tubes cylindrical, as long as carapace and following segments put together, and packed with multiserial eggs.

Male: Much smaller than female in size. Entire length 1.51, carapace 0.46×0.69, 2nd thoracic segment 0.16×0.54, 3rd 0.13×0.44, 4th 0.15×0.28, 5th 0.10×0.24, genital segment 0.10×0.23, abdomen 0.38 long, 1st segment 0.10×0.18, 2nd 0.11×0.10 and 3rd 0.16×0.13. Color as in female.

Carapace same as that of female, but followed by thoracic segments more rapidly narrowing backward. Fourth segment 2/3 as wide as carapace and arched triangularly on hind border. Fifth segment only slightly smaller than the preceding segment, beneath which it is not concealed. Genital segment barrel-shaped, with widely round sides and truncate both in front and behind. Abdomen relatively large-sized and composed of 3 segments, of which the last is somewhat longer than others.

First antennae extending beyond cephalic margin farther than in female and fringed with relatively longer spines. Second antennae resemble those of that sex, but differ in the armatures which they carry, and are armed with 3 curved terminal spines and a pectinate subterminal one, in addition to lanceolate process. First maxillae somewhat stouter than in female. Second maxillipeds also more powerful, and entirely different in structure. They are prehensile limbs made up of palm and claw. Palm elongate; its inner surface flattened on inner side to form a longitudinal area which is delimited by finely serrated, parallel borders and provided with 2 short plumose spines on its surface near base. Claw slender, also elongate, sharp and curved inward at the apex, which closes down against the base of palm. It is furnished with 2 sharp simple spines near its origin, 1 on each of 2 opposite sides, and with a series of closely adjoining

short transverse ridges on inner surface extending over almost entire length, which give a serrated appearance to the border in lateral view.

In other points as in female.

Remarks: The present parasite has been referred by YAMAGUTI to BASSETT-SMITH's *tetradonis* reported from Bombay. If the foregoing description and figures be carefully compared with those given by BASSETT-SMITH, considerable differences between the two forms may be noted. They differ from each other not only in the structure of mouth parts, but also in the disposition of spines on the legs. YAMAGUTI's assignment appears to me to be founded on the superficial resemblance in the general body shape and on the fact that both of them are parasitic on the fishes of the same family. The Japanese specimens, on the other hand, bear a certain resemblance in the general appearance to *Irodes gracilis* (HELLER), which is the parasite of *Zygaena malleus* from Java. This species is quite different in the constitution of appendages both from Indian and from Japanese specimens. It is apparent that the Japanese *Irodes* is distinct from the Indian *Irodes* and represents a new species, whose name is associated with that of Dr. YAMAGUTI.

YAMAGUTI did not give any definite host name, confining himself to record it as tetraodontid fishes. GUSSEV's *tetraodontis* from *Spheroides pordalis* in U. S. S. R. may probably belong to the present species though he does not give any detailed description.

Family Chondracanthidae
Subfamily Chondracanthinae
Genus *Brachiochondria* n. gen.

Female: Cephalothorax distinct from the rest of body, with well-developed carapace dorsally and divisible into 2 portions ventrally; anterior portion depressed, carrying a pair of ventrally turning lateral processes besides 2 pairs of antennae, and posterior portion swollen and with mouth parts. Thoracic segments entirely fused into a voluminous trunk, bearing a small pyramidal abdomen at caudal end. First antennae lamellar, 2nd antennae hamate and mouth parts as in other chondracanthids. Thoracic legs entirely absent. Caudal rami present, rudimentary. Egg cases containing eggs arranged in several rows.

Male: Dwarf. Cepahlothorax indistinctly separated from trunk, occupying far greater part of body. Trunk without segmentation. First antennae absent, second antennae hamate and mouth parts ordinary. No leg rudiment. Caudal rami present.

Type species: *Brachiochondria pinguis* n. sp.

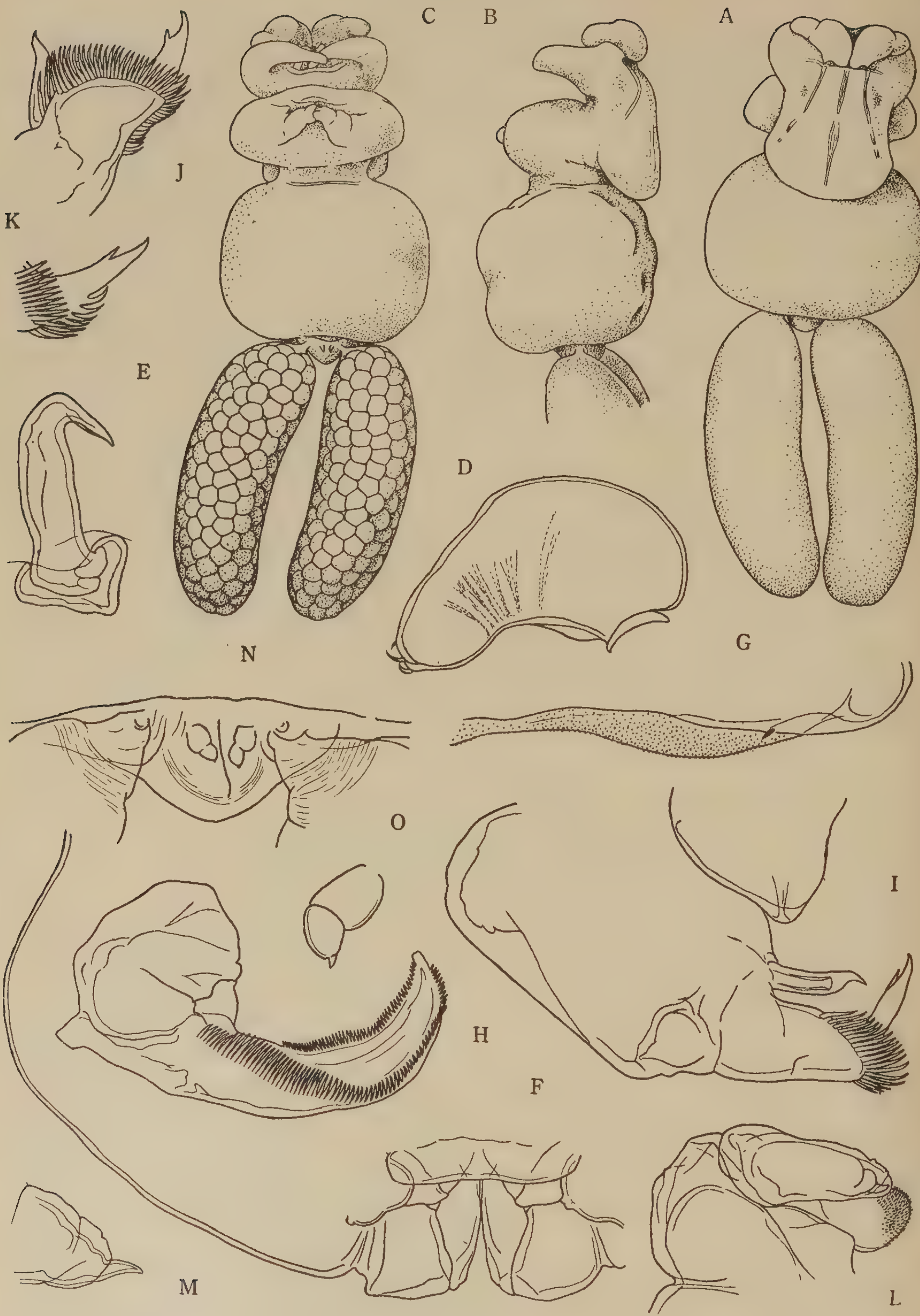

Fig. 4. *Brachiochondria pinguis* n. gen. & n. sp., female.
A, dorsal view; B, lateral view; C, ventral view; D, 1st antenna; E, 2nd antenna; F, mouth parts; G, labrum; H, mandible; I, maxilla and 1st maxilliped; J, apical part of 1st maxilliped; K, same, inner view; L, 2nd maxilliped; M, apical part of endopodite of same; N, posterior end of body, ventral view; O, caudal ramus. A–C ×23.3, D ×83, E, F, N ×120, G–J, M ×485, K ×590, L ×180, O ×340.

Brachiochondria pinguis n. sp.

(Figs. 4 & 5)

Material: 23 females and 9 males obtained from 7 host individuals. A single host was infected by 6 females in the maximum.

Habitat: On the floor of buccal cavity of host in the region between the lower jaw and tongue. The female encircles the base of a mammiform papilla of host skin with curved lateral processes of cephalothorax, standing on its head at right angles to the buccal floor, and clings to the papilla with its hook-like 2nd antennae. It buries, further, its anterior portion deep into the furrow of the host skin made between the papilla and the surrounding ridge and thus strengthens the security of fixation. The papilla and surrounding ridge may probably have resulted from the reaction of host against the irritation caused by the parasite. Male attaches to the female at the caudal end. When 2 or more females are found simultaneously on a single host, the males present are smaller than the females in number.

Female: Holotype. Body plump, swollen laterally as well as dorsiventrally, entire length 1.78, carapace length 1.00, width at anterior end 0.86, same at posterior end 0.74, width of ventral swelling of cephalothorax 1.00, width of neck 0.49, length, width and thickness of trunk $0.97 \times 1.20 \times 1.06$, abdomen 0.17×0.28, egg cases 1.46×0.54 (all in mm.). Color white, egg cases yellow.

Caphalothorax divisible into 2 portions. Anterior portion depressed and covered dorsally by well-defined carapace which extends back over posterior portion. Carapace nearly quadrangular, bilobed in front, well round behind, somewhat reentrant on the sides and carrying a pair of ventrally directing, curved processes at either antero-lateral angle. The processes taper distally and meet with or overlap each other on the midline, thus together with the carapace making an incomplete ring as a whole, which encircles the papilla of host skin. Posterior portion of cephalothorax strongly swollen ventrally as well as laterally, forming a transverse, prolate spheroidal bulge, and contracted to a very short neck before joining the trunk. The latter voluminous, globular, about as long as carapace, wider and thicker than long and without segmentation save that a shallow groove traverses ventral surface at about the middle. Genital segment and abdomen coalesced together and represented by a small conical protuberance at caudal end of trunk.

First antennae broadly lamellar, of a crescentic shape, attenuating terminally, very indistinctly 2-jointed and sparingly setaceous at the end. Second antennae situated close behind 1st antennae, relatively feeble and hook-like, having straight shaft and short curved, sharp apex. Oral parts far apart from them and crowded at the top of the posterior swelling of cephalothorax. Labrum finely granular

on free border. Mandibles falcate, densely fringed by numerous sharp teeth along 2 edges; teeth on the basal portion of posterior edge attaining to unusual length. Maxillae triangular, without spine. First maxillipeds consist of broad base and 2 rami. Exopodite armed with long spines arranged along terminal border in a row and tipped by unequally bifurcate claw which carries a few basal spines on outer side. Endopodite short, about as large as terminal claw of exopodite and rod-shaped, ending in spiniform apex. Second maxillipeds biramous, basal joint broad, exopodite blunt at the tip and provided with a tiny claw, and endopodite a little longer and broader than exopodite and blunt at the apex where it is densely covered with fine spinules. Legs entirely missing. Caudal rami placed on the ventral face of caudal protuberance on either side of midline, very small, 2-jointed and tipped by vestigial spine. Egg cases about as long as body, rather thick, banana-shaped; eggs multiseriate.

Male: Allotype. Dwarf, bent ventrally, 0.32mm. long, 0.21mm. thick. Color whitish and pellucid.

Cephalothorax strongly convex dorsally, and more or less rugose, while nearly flat ventrally. Front produced on the median in a short quadrangular lobe. Trunk projecting from posterior end of cephalothorax ventrally, but not definitely delimited from it and without any trace of segmentation.

First antennae missing. Second antennae hamate, broad at base and strongly curved, with their apices reaching the medio-frontal lobe of carapace. They bear

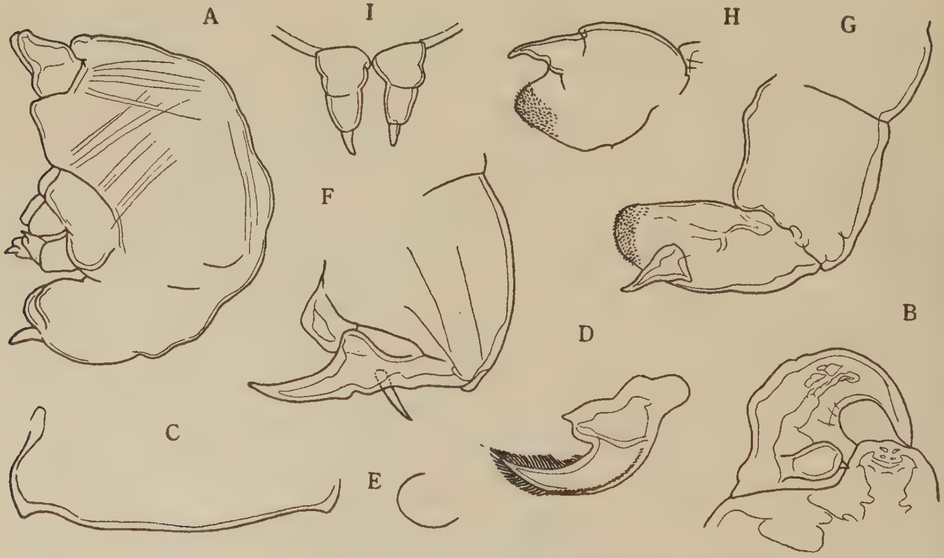

Fig. 5. *Brachiochondria pinguis* n. gen. & n. sp., male.
A, lateral view; B, 2nd antenna, dorsal view; C, labrum; D, mandible; E, maxilla; F, 1st maxilliped; G, 2nd maxilliped; H, apical part of same; I, caudal rami. A ×135, B–I ×485.

on dorsal face close to the base a small oval lamina tipped by a short spine (which may represent the rudiment of 1st antenna). Labrum smooth on margin. Mandibles with cutting blade falciform, tapering to a point and thickly fringed by long spinules along 2 edges. Maxillae semicircular, unarmed. First maxillipeds with broad base and sharp unguiform apical joint which bears much smaller spiniform endite. Second maxillipeds not prehensile, rather broad, penultimate joint produced in a round spinulose protuberance on inner side at distal end and terminal claw nearly straight, acuminating to tip. Legs absent. Caudal rami 2-jointed, tipped with a short spine.

Remarks: Judging from the constitution of the 2nd antennae, mandibles and 2 pairs of maxillipeds there may be no doubt in that the present parasite belongs to the family Chondracanthidae. It lacks an elongate neck which characterizes the Lernentominae[6] and its mouth parts are not removed from the antennae so far back as in this subfamily. It is deprived of lateral wing-like expansions such as those found in the Pharodinae[5]. Complete union of all trunk segments into a spheroidal piece and the absence of 2 pairs of legs on the present parasite strongly remind us of the characters found in *Blias* KRØYER which is a member of the subfamily Chondracanthinae. The new parasite appears, therefore, to be more or less close to this genus and may most appropriately be located in this subfamily. Although OAKLEY[7] presumed the presence of legs in the genus *Blias*, WILSON[10] definitely stated their absence based on the examination of new material. Quite recently, however, CAUSEY[2] noted the single pair of legs in his specimens which he definitely showed in his figure (1955, Fig. 1). At any rate, absence of legs together with the presence of ventrally directing processes on the sides of head may justify the setting up of a new genus for the present parasite.

Family Lernaeopodidae
Genus *Clavellopsis* WILSON, 1915
Clavellopsis hugu YAMAGUTI, 1939
(Figs. 6 & 7)

YAMAGUTI 1939, p. 560, Pls. 50–51, figs. 155–170.

Material: 9 females, 2 younger females and 7 males obtained from all 8 individuals of host.

Habitat: Adhering to the roof or floor of buccal cavity. In one case, a female was associated with 2 males, but in other cases it had either a single male or none.

Female: Body plump, length of cephalothorax 2.86, length, breadth and thickness of trunk $1.47 \times 1.71 \times 1.21$, caudal process 1.00 long, egg tubes 2.22 long (all in mm.). Color white, egg tubes containing yellowish eggs.

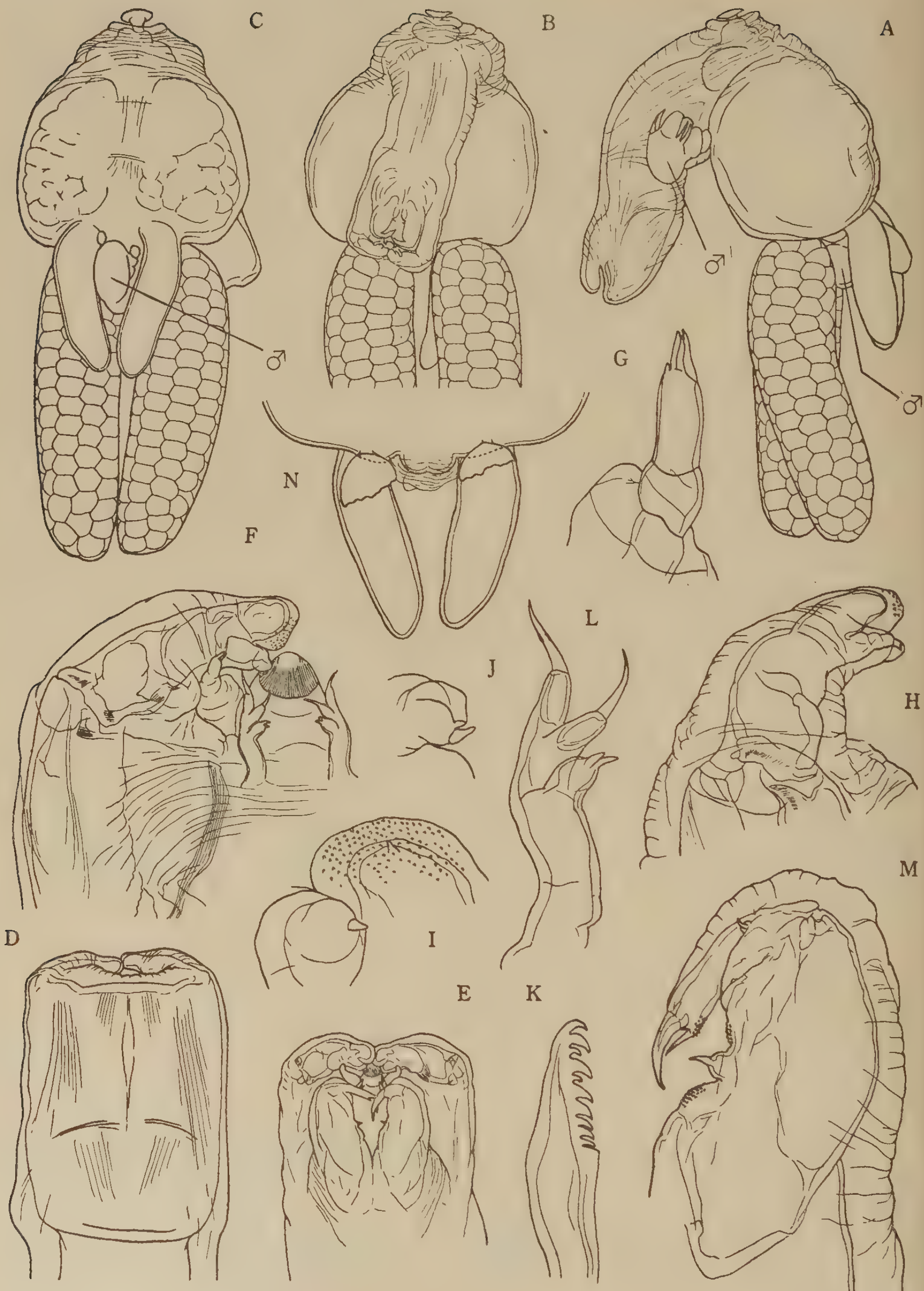

Fig. 6. *Clavellopsis hugu* YAMAGUTI, female.

A, lateral view; B, head in ventral view and trunk in dorsal view; C, head in dorsal view and trunk in ventral view; D, carapace, dorsal view; E, same, ventral view F, same with 2nd maxilliped, ventral view; G, 1st antenna; H, 2nd antenna; I, apical part of same, inner view; J, inner ramus of same; K, mandible; L, maxilla; M, 2nd maxilliped; N, caudal end of trunk, with egg tubes removed, dorsal view. A–C ×19, D, E ×41, F ×120, G, I, J, L ×340, H×135, K ×490, M×175, N ×28.

Cephalothorax prolonged, but relatively broad, vermiform, strongly flexed dorsally as well as posteriorly, extending a trifle beyond caudal end of trunk, and with integument rugose. Carapace more or less distinct, occupying about 1/3 of cephalothoracic length, longer than wide and rectangular in shape. Trunk longer than broad, well swollen both laterally and dorsiventrally, ovoidal in shape and carrying a pair of lanceolate processes on caudal margin, one on either side of midline. These lie ventrally to egg tubes, extending backward for about the length of trunk. Caudal margin of trunk produced into a bilobed lobe on midline and somewhat dorsally to the paired processes. Egg tubes more than twice as long as paired processes, relatively large in diameter and packed with eggs arranged in several rows.

First antennae 3-jointed, 1st joint broad and comparatively massive, but other joints slender and rod-like; 2nd joint shorter than 3rd which is sparingly spinous at the end. Second antennae turned inward at right angles, with their biramous apices meeting on midline and hanging over mouth tube. Exopod broader than and extending beyond endopod, round at the end, where it is covered by fine granules besides bearing a short conical spine; endopod also blunt and with 2 short spines. Mouth tube conical, opening forward. Mandibles have blade reinforced by 8 sharp, recurved teeth, of which 2nd to 4th from the apex interpose a feebler tooth between consecutive 2. Maxillae bipartite, each lobe ending in a sharp spine; endite short, surmounted with 2 short spines. First maxillipeds displaced to the posterior end of cephalothorax, completely fused together into a very short conical structure and in line with trunk. They bear glandular tubercles at the base, one on each side. Bulla shaped like a nail head. Second maxillipeds placed just behind other mouth parts and close to the midline. Their palm fusiform, furnished at about the center of inner border with a conical papilla surmounted by a short spinule and with small granulated area proximally as well as distally to it; finger nearly straight, with a tiny basal spine and a sharply pointed, curved terminal claw which is associated at the origin with a short accessory spine as well as granulated area.

Juvenille female: Cephalothorax 1.40 long, maxilliped 0.29 long, trunk 0.89 long (all in mm.).

Cephalothorax huge in proportion to the size of body. Carapace represented by an ellipsoidal bulge of cephalothorax, occupying more than half of its length. Trunk smaller than carapace and with caudal processes rudimentary. First maxillipeds relatively longer than in the adult and with more distinct basal gland swellings.

Male: Body is bent in a V-shape, 0.74 long measured as it is, carapace 0.52 long, 0.32 thick, trunk 0.46 long, and 0.21 thick (all in mm.); white and pellucid.

Cephalothorax with carapace distinct and convex, more or less irregular ventrally and making a triangle in lateral aspect. Trunk well developed, almost as long as carapace, from which it is well demarked and with which it makes an obtuse angle. It is cylindrical, nearly straight, of uniform width throughout, but round at caudal end and has no trace of segmentation.

Cephalic appendages and oral tube large in size, projecting forward. First antennae styliform, composed of 3 subequal joints and terminating in 3 spines. Second antennae bilobed, endopodite ovate, unarmed and exopodite 2-jointed, extending beyond endopodite. First joint of exopodite elongate, distinctly bordered basally and with a few tubercles on outer margin near the end; 2nd joint armed with marginal spinules on outer side besides with a stout apical claw. Second maxillae resembling those of female, forked into 2 spine-tipped, styliform lobes and bearing a short endite tipped by 2 tiny spinules. First maxillipeds powerful; palm oblong, produced on inner margin near distal end into a finely granulated,

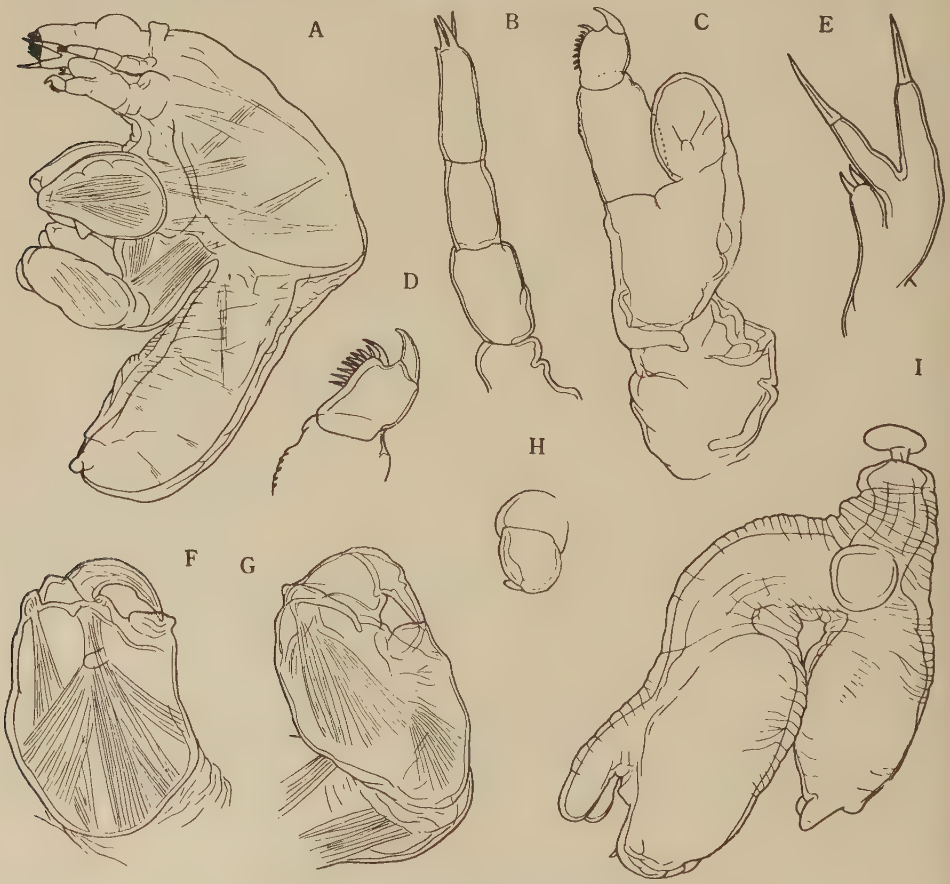

Fig. 7. *Clavellopsis hugu* Yamaguti.

A–H, male; A, lateral view; B, 1st antenna; C, 2nd antenna; D, apical part of same; E, maxilla; F, 1st maxilliped; G, 2nd maxilliped; H, caudal ramus; I, young female, lateral view. A ×85, B, C, E ×340, D, H ×490, F, G ×175, I ×41.

molar-like protuberance against which an acuminate, strongly curved terminal claw acts. Second maxillipeds as stout as preceding limbs, resembling in structure and armed with similar inner distal protuberance on the palm, which is, nevertheless, somewhat narrower and fusiform. Succeeding limbs missing. Caudal rami papilliform, 2-jointed and tipped by a rudimentary spinule.

Remarks: Although my specimens are largely in accord with the type, there are some points of minor differences. These are found in the constitution of the 2nd antennae and 2nd maxillae of the female. The shape of body is also somewhat different from that figured by the original author. This, however, is subject to changes due to the conditions of fixation to some extent. Individual variations may occur also. Even among my specimens, there is the one in which the caudal processes are reduced to short bulges and is another where one of those processes is rudimentary while the other well-developed. Egg tubes appears to contain less numerous eggs than in the type. Since the holotype and paratype were not accompanied by the male, the foregoing description is the first one to be published.

References

1. Bassett-Smith, P. W., 1898. Some new parasitic copepods found on fish at Bombay. Ann. Mag. Nat. Hist., (7) Vol. 1, pp. 9–17, Pls. 1–7.
2. Causey, D., 1955. The external morphology of *Blias prionoti* Kröyer, a copepod parasite of the sea robins (*Prionotus*). Inst. Mar. Sci., Vol. 4, pp. 7–12.
3. Delamare-Deboutteville, C., 1951. Présence de la sousfamille des Pharodinae Illg (copépodes chondracanthidae) en Méditerranée et remarques sur la classification et la biologie des Chondracanthidae. Arch. Zool. Exp. et Gén., Vol. 87, notes et revue, pp. 139–155.
4. Гусев, А.В., 1951. Паразитисеские Copepoda с Некбторых Морских рыб. Паразитол. сборн. Зоол. Инст. Акад. Наук СССР, Vol. 13, pp. 394–463.
5. Illg, P. L., 1948. Pharodinae, a new subfamily of Chondracanthidae (Crustacea: Copepoda) and a description of *Pharodes biakensis* n. sp., from New Guinea. J. Wash. Acad. Sci., Vol. 38, pp. 404–412.
6. Leigh-Sharpe, W. H. and C. L. Oakley, 1927. Lernentominae. A new subfamily of Chondracanthidae (Crustacea: Copepoda), with a description of *Oralien triglae*. Parasitol., Vol. 19, pp. 455–467.
7. Oakley, C. L., 1930. The Chondracanthidae (Crustacea: Copepoda); with a description of five new genera and one new species. Ibid., Vol. 22, pp. 182–201.
8. Shiino, S. M., 1955. Copepods parasitic on Japanese fishes. 9, Family Chondracanthidae, subfamily Chondracanthinae. Rep. Fac. Fish., Pref. Univ. Mie, Vol. 2, pp. 70–111.
9. Wilson, C. B., 1911. North American parasitic copepods belonging to the family Ergasilidae. Proc. U. S. Nation. Mus., Vol. 39, pp. 263–400, Pls. 41–60.
10. ———, 1932. The copepods of the Woods Hole Region, Massachusetts. U. S. Nation. Mus. Bull. 158, pp. I–XIX, 1–635, Pls. 1–41.
11. Yamaguti, S., 1936. Parasitic copepods from fishes of Japan. Pt. 1, Cyclopoida I, pp. 1–8, Pls. 1–8.
12. ———, 1939. Parasitic copepods from fishes of Japan. Pt. 6, Lernaeopodoida, I. Vol. Jubil. Prof. S. Yoshida, Vol. 2, pp. 529–578, Pls. 34–58.
13. Yü, S. C., 1935. Studies on the parasitic copepods of China belonging to the family Chondracanthidae. Bull. Fan Mem. Inst. Biol., Vol. 6, no. 16, pp. 1–16, Pls. 1–4.

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Copepods Parasitic on Japanese Fishes

15. Eudactylinidae and Dichelesthiidae

(*With 7 Text-figures*)

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Both the Eudactylinidae and the Dichelesthiidae are exclusively the gill parasites, one occurring mostly on elasmobranchs and the other on teleosts. The forms belonging to the former are usually strongly built, being clothed in thick chitin, and have appendages well-developed and plentifully supplied with setae and spines. Those of the latter have rather thin integument and are far more degenerated than those of the former in the constitution of body. In them, the thoracic segments are more or less united, the abdomen is rudimentary, and the legs are reduced in number and simplified in structure. The two groups, however, are related with each other in having the hook-like second antennae, which are used for prehension, and in not having the male dwarfed. In fact, they were included together with two other groups (Anthosomidae and Pseudocycnidae) under the family Dichelesthiidae and each was treated as subfamily by WILSON (1922) until he later (1932) raised each to the rank of family.

The present article contains the full description of a new species of Eudactylinidae and the same of four species of Dichelesthiidae, of which two are new to science and one is new to Japan. The type specimens of the new forms are to be preserved in the Prefectural University of Mie.

Family Eudactylinidae

Genus *Nemesis* RISSO, 1826

Nemesis macrocephalus n. sp.

(Figs. 1 and 2)

Occurrence: 2 egg bearing females on the gills of *Carcharinus melanopterus* (QUOY et GAIMARD) taken off Hamazima, Mie Prefecture, August 6, 1956. No male. One of the females is selected as holotype.

Female: Body thick-set, not depressed dorsiventrally, but cylindrical and powerfully built, having strongly chitinized integument. Entire length (excluding caudal rami) 3.14, carapace 1.21×1.00, 2nd thoracic segment 0.79×1.29, 3rd 0.54 ×1.22, 4th 0.50×0.97, 5th 0.42×0.71, 6th (genital segment) 0.19×0.39, abdomen 0.26 long, 1st segment 0.08×0.29, 2nd 0.08×0.23, 3rd 0.11×0.19, egg string 5.78

long (all in mm.). Color yellowish brown on dorsal face, with vermilion-colored linear pattern along segmental borders; egg strings whitish.

Carapace large-sized, occupying 2/5 the body length and longer than its own width. It is obovate in shape and slightly overlap 2nd thoracic segment posteriorly. The latter wider than carapace, with widely round anterior shoulders and followed by segments regularly decreasing in width and length backward. Second to 4th

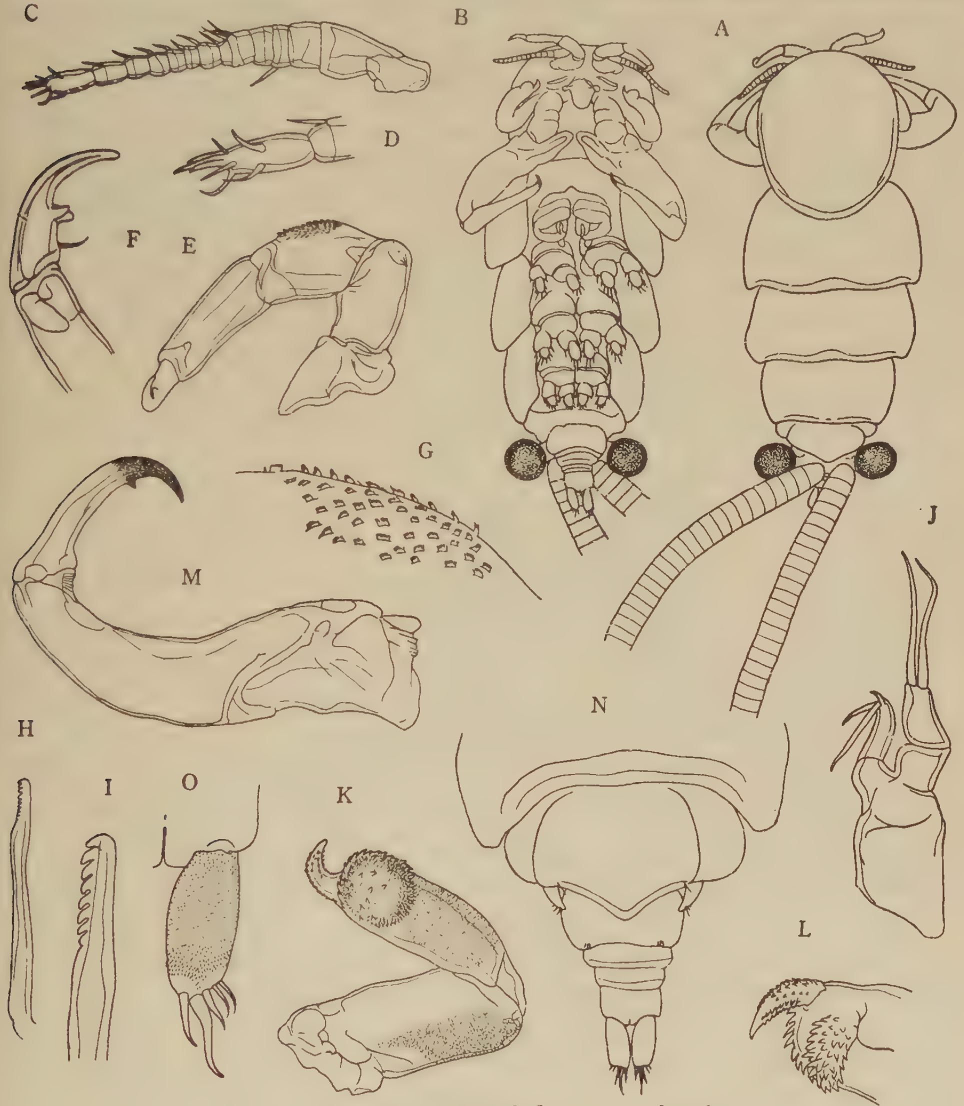

Fig. 1. *Nemesis macrocephalus* n. sp., female.

A, dorsal view; B, ventral view; C, 1st antenna; D, tip of same; E, 2nd antenna; F, tip of same; G, surface ridges on 3rd joint of same; H, mandible; I, cutting edge of same; J, maxilla; K, 1st maxilliped; L, tip of same, inner surface; M, 2nd maxilliped; N, posterior end of body, dorsal view; O, caudal ramus, ventral view. A, B ×18.6, C, E, K ×83, D, H, J ×170, F, L, O ×120, G ×340, I ×485, M, N ×41.

segments strongly convex above, with well-developed dorsal plate, which is trapezoid, showing truncate hind border, and slightly overlap the succeeding segment. Dorsal plate turns downward on either side and passes around it to ventral surface so as to extend medially for a short distance, thus leaving the latter deeply grooved along midline. Fifth segment small in size, narrowly round on sides, produced in a V-shape in the rear and with a medio-dorsal bulge which is bounded by a pair of arcuate furrows. Dorsal plate undifferentiated, tergal face continuing directly to sternal face on either side. Genital segment abruptly narrowed, half as wide as preceding segment and shorter than its own width. It has round sides and truncate hind border and carries a pair of spine-tipped, dorsal tubercles close to caudo-lateral angles. Its ventral surface trilobed in front while slightly reentrant behind. Abdomen 3-segmented, only slightly longer than preceding segment, but narrower and tapering backward. First 2 segments of equal length, shorter than the last and transversely linear. Last segment squarish save for a slight medio-caudal projection. Carapace and first 3 free segments thickly covered with fine granules on tergal surface and the rest on all sides except narrow transverse zone along hind border.

First antennae filiform, composed of more than a doezen of short joints and contracted between first 2 joints. Second joint longest and widest of all, succeeding ones gradually diminishing in length and only slightly in width up to the 7th, from which the joints grow longer a little by little though not widening; terminal joint almost as long as the 2nd. First 3 and 5th joints spineless, 4th with a single spine on posterior side, 6th with 3 on anterior side and each of following joints with a solitary spine on the same side except the last which carries several terminal and subterminal spines. Second antennae 5-jointed, prehensile, with geniculation intervening between 2nd and 3rd joints. First joint short, 2nd and 3rd subequal to each other in length and thickness, but the latter covered with comb-like tiny short ridges in an oval area of outer side, 4th somewhat longer and slenderer than the preceding, unarmed and 5th shortest of all, curving and tapering toward narrowly blunt tip and armed at the middle of inner margin with 2 small conical processes arranged side by side, besides with a hair just behind. Mouth tube blunt. Mandibles elongate, having blade cut into recurved teeth. First maxillae missing. Second maxillae placed just outside the mouth tube and composed of broad cylindrical base and 2 narrower, more or less crooked, 2-jointed rami; inner ramus tipped by 2 long spines pointing terminally and outer ramus with 2 shorter, unequal spines turned backward as well as with an additional, rudimentary one. First maxillipeds stout, 3-jointed. First joint about as long as 2nd, but thicker and finely granulated on dorsal half of its outer surface. Second joint claviform, similarly granulated almost over entire outer surface and carrying at distal end of this surface a prominent

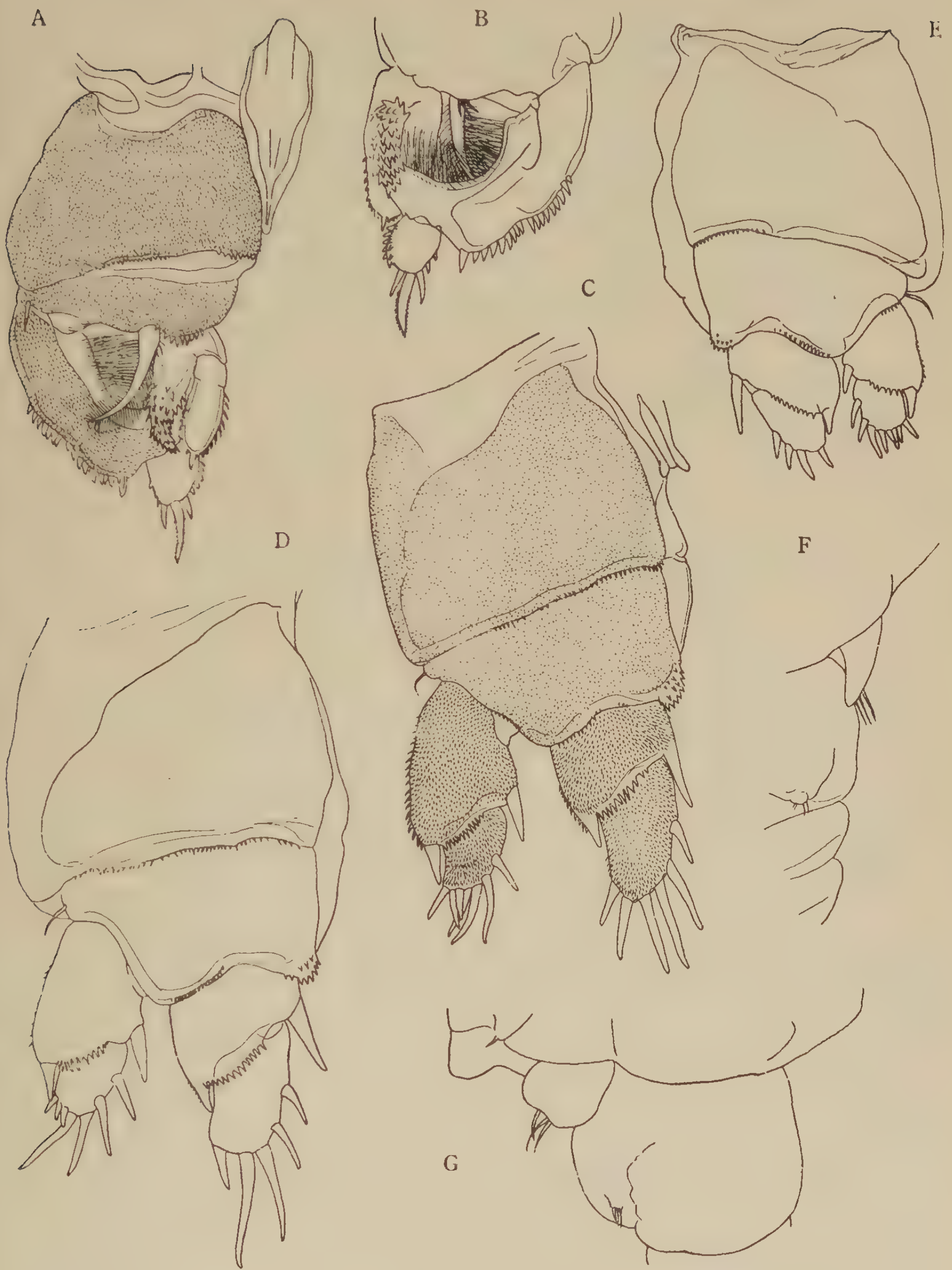

Fig. 2. *Nemesis macrocephalus* n. sp., female.

A, 1st leg, anterior surface; B, 2 rami of same, posterior surface; C, 2nd leg, anterior surface; D, 3rd leg; E, 4th leg; F, lateral part of 5th and 6th thoracic segments, showing 5th leg rudiments, dorsal view; G, same, lateral view. ×120.

hemispherical knob, which is encircled by sharp spinules around the circumference and is scattered by similar ones on the surface amid the granules. On inner surface at the point opposite to that knob, there is a short thick process which stands out of the surface like a thumb, pointing to the ventral side, and is arrayed in acuminate spinules. Claw short, strongly curved ventrally, sharp at the tip and covered with tiny spinules arranged in lines. Second maxillipeds prehensile, 2-jointed, very powerful and exposed dorsally, extending far beyond sides of carapace. Basal joint is insensibly curved in the form of S, somewhat attenuating distally and provided with a strong musculature which gives rise a broad ridge on the sternum reaching the base of mouth tube. Claw is nearly straight, but abruptly curved at tip, which ends in a sharp point and extends over the center of basal joint when closed; the tip is so strongly chitinized as to be colored in dark brown and bears a tiny conical, inner process.

First 4 pairs of legs biramous, having both rami as well as protopodite well-developed and 2-jointed, and similar in constitution in all except 1st which is very peculiar in the structure of rami. First legs have basal joint of exopodite transformed into a narrow flattened lamina, curved in the form of a half ring; distal part of the joint is again narrowed, ending in claviform apex and lie beneath the endopodite so as to reach near its base. The joint is armed with a row of short acuminate spines on outer margin in the distal half of broader basal region, and thickly fringed by long setae on inner margin except in claviform apical region which is clothed in spinules on all sides, Anterior surface of the joint is closely covered with granules or fine spinules save the narrow inner marginal zone and entire posterior surface are smooth. Second joint of exopodite is attached to the external margin of 1st joint at the base of the narrowed apical region, upon which it stands at right angles. It is ovate, small in size, marginated by 2 rows of tiny spinules on the inside, whereas by a few ones on the outside and tipped by 3 stouter spines, of which the central one is pectinate and longer than others. Endopodite of 1st legs is short and exhibits a seeming bifurcate appearance on account of that the 2nd joint arises from near the base of 1st joint and the two stand side by side. First joint attenuating to the end, slightly incurvate near apex and covered with short spinules on the surface. Second joint is equally narrow, but round at apex, ending in a short spine, and is marginated with feebler spinules, which are absent from the surface. Protopodite of 1st legs is broadly lamellar and roughly trapezoid, being broader distally than proximally. Proximal joint of protopodite is far greater than distal one, combined with the corresponding fellow of the other side by a narrow navicular sternal plate with pointed ending, and thickly covered on anterior surface with granules, which develop into spinules along the line of articulation giving it a serrated appearance. Second joint is short, similarly granulated on surface and spinulose on the margin

at the base of endopodite, and bears a well-developed plumose spines just outside of it as well as a simple short spine at outer distal angle. Second to 4th legs are similar to one another in constitution, subequal in size and have rather simple rami. Protopodite lamellar, 1st joint rectangular and 2nd joint trapezoid, obliquely cut on the outside where it bears exopodite and more or less sinuate on the terminal border, to which endopodite is inserted. Both the joints thickly granulated on both anterior and posterior surfaces and finely serrated along distal border on the former surface alone; 2nd joint with a short external spine close to the base of exopodite. Sternal plate narrow, navicular and bifurcate at free end. Two rami resembling each other in size as well as in structure and with surface granules. First joint of both rami armed with a stout spine at distal end on both outer and inner sides and with spinule row on distal as well as on external borders. Second joint reinforced by similar spines, whose number present on each of legs are shown in the following table;

	2nd leg	3rd leg	4th leg
2nd joint of exopodite	7	7	8
2nd joint of endopodite	6	5	4

Fifth legs rudimentary, attached to posterior margin of the segment on dorsal level, projecting backward on either side of genital segment and visible from above. They are tiny round laminae tipped by 3 short spinules. Caudal rami oblong ovate, with granulated surface and ending in 5 spines, of which 2 are subequal, interposing a longer one and accompanying feebler 2 just outside. Egg strings exceed much the length of body and enclose flattened uniserial eggs.

Male: Unknown.

Remarks: The present species may be characterized by its large-sized carapace and by the 4 succeeding segments which gradually decrease in size from before backward. Differences from other species of the genus are shown in the following table:

	Carapace: body length	2nd to 5th segments of thorax	5th segment
macrocephalus n. sp.	0.39:1	decreasing in size backward	narrower than 4th, but not abruptly
pilosus PEARSE[9]	0.33:1	〃	〃
lamna (RISSO)[2,6,7,13,15]	0.25:1	equal in size	equal to 4th
lamna var. *sinuata* VALLE[2]	0.27:1	〃	abruptly narrower than 4th
robusta VAN BENEDEN[1,2,3,6,7,12]	0.29:1	subequal in size	〃
atlantica WILSON[12,13,14]	0.28:1	〃	〃
versicolor WILSON[11]	0.29:1	〃	〃
pallida WILSON[13,14]	0.29:1	〃	narrower than 4th, but not abruptly

Family Dichelesthiidae

Genus *Hatschekia* Poche, 1902

Hatschekia fusiformis n. sp.

(Fig. 3)

Occurrence: 3 females occurring on the gills of *Hoplostethus mediterraneus* C. & V. taken off Minabe, Wakayama Prefecture, at a depth of 100–200 fathoms, May 1933. No male.

Holotype: Female. Body elongate cylindrical and not depressed dorsi-ventrally, 2.60 long, carapace 0.34×0.41, trunk 2.29×0.63 and egg string 3.04 long (all in mm.). Color whitish in alcohol.

Carapace oblong, broader than long, small in size and about 1/7 as long as trunk, from which it is distinctly bordered. Frontal margin salient, slightly bilobed and with 3 tiny tubercles, disposed one on the midline and the other close to either side and somewhat in front. Sides widely round and hind border a trifle reentrant. All thoracic segments entirely fused into an elongate fusiform trunk which is equally swollen all around the axis. Trunk is gradually narrowed from 1/3 of its length forward and from 2/3 backward, constricted at fore end and bears another constriction a short distance behind. The region limited by these constrictions forms a sort of neck which measures less than half the widest calibre of trunk. First pair of legs present at fore end, where 1st constriction occurs, and 2nd pair just in front of 2nd constriction. Caudal end narrowly round and without abdomen differentiated, caudal rami attaching themselves directly to the trunk on ventral level. Egg strings longer than body, adhering to the sides of trunk just in front of its end; eggs flattened, uniseriate.

First antennae 5-jointed. First 4 joints successively decreasing in length and fringed by acuminate hairs on anterior margin, besides very minute scattering ones; 3rd with a stout additional hair on posterior side and this of 4th very tiny. Fifth joint as long as 3rd, contracted near apex and plentifully supplied with terminal and subterminal hairs. Second antennae hook-like, not very powerful. Claw well curved in a sickle-shape, acuminating to tip, which is bluntly pointed and reaches the base of palm; it bears a tiny spinule on inner border near base. Palm broad, convex on the outside, slightly concave on the inside and closely granulated on the surface. Mouth tube triangular. Maxillae just outside the mouth tube and composed of 2 tubercles standing side by side; inner tubercle spineless, while outer tubercle carrying 2 unequal, externally directing spines. Maxillipeds prehensile, consisting of 2 broad basal and 2 attenuate apical joints. First joint 2/3 as long as 2nd, which bears acuminate inner proximal spine, 3rd straight, furnished with a feeble terminal spinules and the last very short, tapering to the tip, which is slightly curved and bifid and reaches beyond the proximal end of 2nd joint,

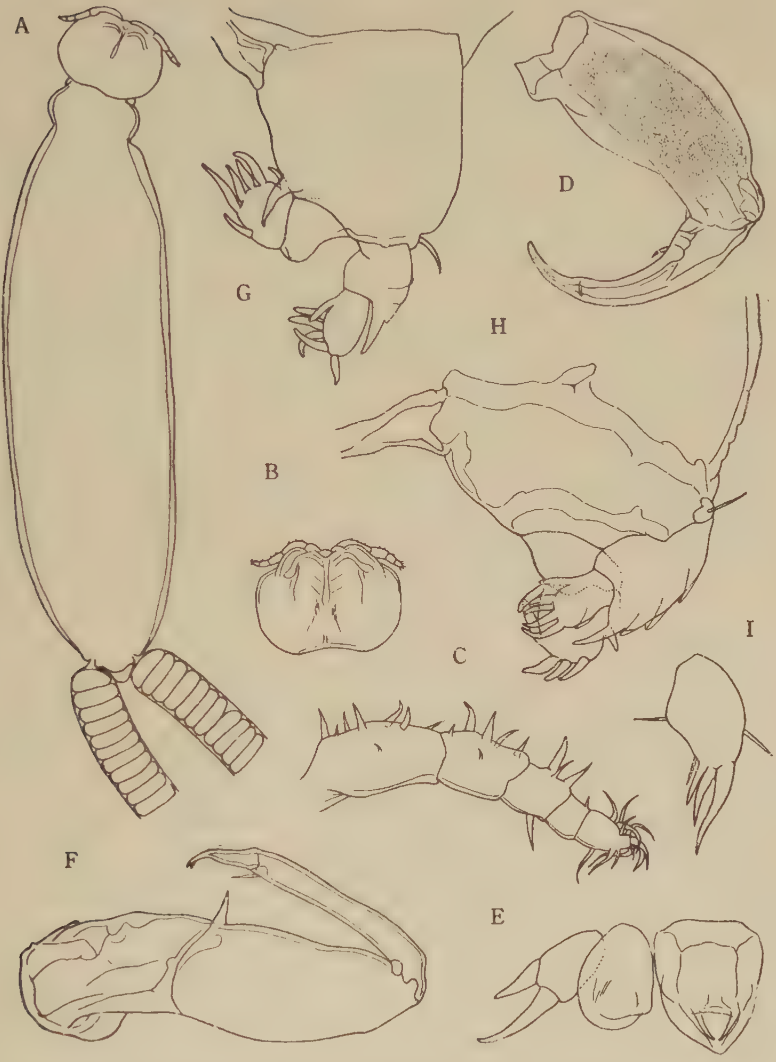

Fig. 3. *Hatschekia fusiformis* n. sp., female.
A, dorsal aspect; B, carapace, dorsal aspect; C, 1st antenna; D, 2nd antenna; E, 2nd maxilla; F, maxilliped; G, 1st leg, anterior surface; H, 2nd leg, posterior surface; I, caudal ramus. A ×34, B ×50, C, D ×200, E–I ×340.

Only 2 pairs of legs present, 3rd pair entirely missing. First pair smaller than 2nd. but both similar in structure and made up of broadly lamellar protopodite and 2-jointed rami. Protopodite of each pair connected across midventral surface with its fellow of opposite side by a slender sternal bar. That of 1st pair has a sharp spine just outside the base of exopodite and another broader one inside the endopodite. Apical joint of both exopodite and endopodite in the same pair armed with 6 spines and basal joint with a single outer distal spine in the former, whereas spineless in the latter. Second pair of legs bear outer

spine on protopodite, but lack inner one. Endopodite has 6 apical spines and exopodite has 5. Basal joint carrying outer distal spine in the latter while spineless in the former. Along outer margin of exopodite, both pairs of legs are ornamented with ridges which have developed into thin laminae free from the surface on their distal margin. Caudal rami turning ventrally, rhombic in shape. They terminate in 4 spines, increasing in length and thickness from within outward, and bears, in addition, a feeble one both on outer and on inner sides.

Male: Unknown.

Remarks: The present species closely resembles *mulli* (VAN BENEDEN)[5,10] in the general appearance of the body, but is different in the absence of caudolateral processes from the trunk. It bears a certain resemblance also to the three forms recorded from Japan by YAMAGUTI[15], *labracis* (VAN BENEDEN)[10], *leptoscari* YAMAGUTI and *branchiostegi* YAMAGUTI. Its trunk, however, is relatively much longer than in these species and has distinct lateral constrictions unlike these. In having the constrictions, it is allied to the species described by WILSON[11] from the West Indies: *albirubra*, *oblonga* and *linearis*. The first of these has three additional constrictions and the frontal carina of carapace, the second has the trunk relatively much shorter than in the new species, carrying the frontal carina at the same time, and the third possesses a longer trunk which bears a pair of swellings just in front of the constrictions. PEARSE's *Hatschekia* sp.[9] from Bahamas is close to the new species in the proportion of the carapace and trunk, which is as 1:7, but it has cordiform carapace and has no constriction on the trunk. There are a few more species showing a similar proportion, though this appears variable to a certain extent in some cases. They are *bougisi* NUNES-RUIVO[8], *elongata* CAPART[4], *hippoglossi* KRØYER[10,13], *cornigera* T. SCOTT[10] and *sargi* (DE LA VALLE)[2]. The new species may be distinguished from them either by the character of carapace or by that of trunk, or by the both. The first of those species has the carapace much wider than in the new species and has no indentation on the trunk, the second possesses rectangular carapace and the trunk of uniform breadth, the third carries caudo-lateral processes, the fourth bears corniform dorsal process on the carapace and the last has much longer trunk which is narrowed near anterior end so as to form a long neck.

Hatschekia cernae GOGGIO, 1905

(Fig. 4)

GOGGIO 1905, p. 219, fig. 3; BRIAN 1906, p. 70; NUNES-RUIVO 1954, p. 483, fig. 2.

Occurrence: 6 females clinging to the gills of *Epinephelus* sp. taken at Naha, Okinawa Is., the Loochoos. No male.

Distribution: Mediterranean and Loochoos (present record).

Holotype: Female. Body elongate cylindrical, almost of uniform width throughout except in caudal region, neither depressed, nor compressed. Integument disjoined from body by a relatively wide intervening space. Length (including integument) 2.00, width 0.50, carapace (excluding integument) 0.35×0.34, trunk 1.63×0.44, egg strings 1.18 long (all in mm.). Color in formalin pale pinkish; egg strings pale yellowish brown.

Carapace ovoidal, nearly as long as wide, slightly emarginate in front, widely round on sides and confluent behind with trunk, boundary between them

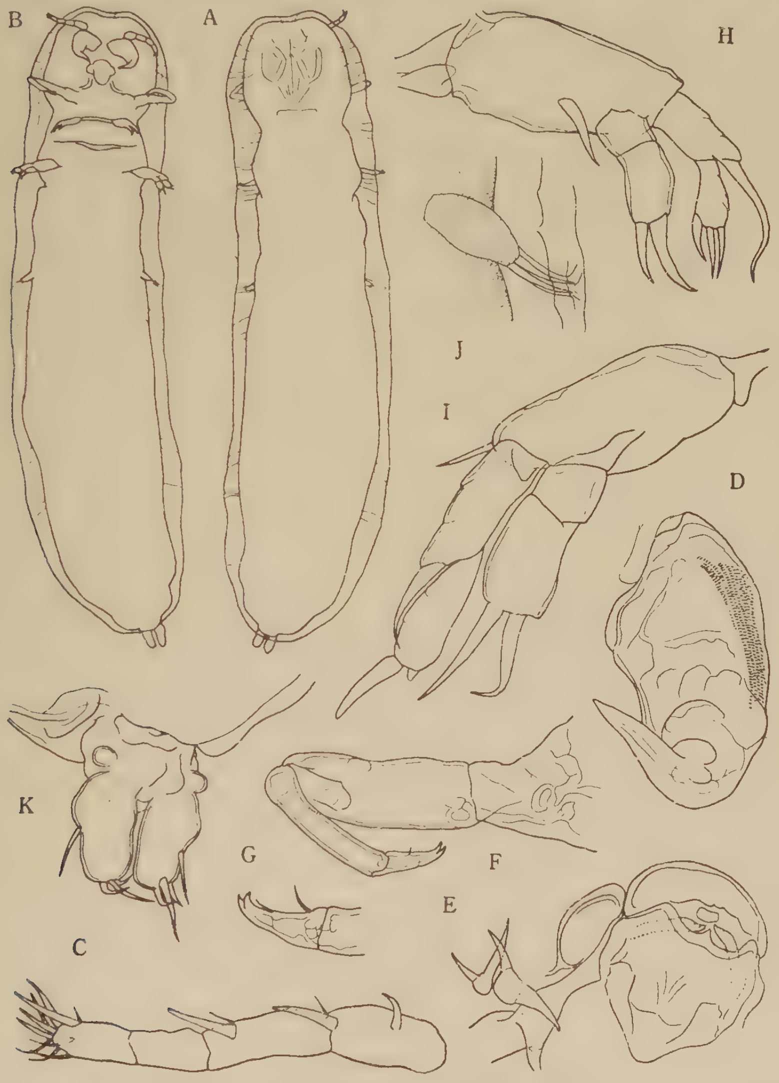

Fig. 4. *Hatschekia cernae* GOGGIO, female.

A, dorsal aspect; B, ventral aspect; C, 1st antenna; D, 2nd antenna; E, mouth tube and maxilla; F, maxilliped; G, tip of same; H, 1st leg; I, 2nd leg; J, 3rd leg; K, abdomen with caudal rami. A, B ×41, C–F ×340, G–J ×730, K ×200.

being made out merely by shallow lateral notches. All thoracic segments entirely coalesced together, forming a cylindrical trunk which leaves no trace of articulation. Trunk about 5 times as long as and almost as wide as carapace, gradually tapering from posterior 1/3 of its length backward and terminating in narrowly round end. It bears a pair of slight lateral constrictions near anterior end just behind 2nd pair of legs. Abdomen represented by an insignificant, irregular-shaped process of caudal end and carrying a tubercle on either side.

First antennae short, 4-jointed and projecting from under surface of carapace a trifle behind the frontal margin. First 2 joints equal in length and longer than succeeding two which are subequal; 1st joint with 2 acuminate spines and a thin hair on anterior margin, 2nd with a single spine and a hair, 3rd unarmed and the last tipped by terminal bundle of spines and hairs. Second antennae feeble, prehensile, composed of palm and claw and placed on each side of midventral line. Palm ovoidal, somewhat convex outside, slightly concave inside and covered with fine spinules on anterior face in a narrow outer zone; claw spiniform, straight and sharply pointed. Maxillae a short distance removed from the base of mouth, locating about halfway between this and the bases of maxillipeds. Each of them consists of 2 tubercles surmounted by 2 acuminate spinules. Maxillipeds feeble, 4-jointed. First joint short, conical, 2nd longer, rod-like and of uniform width, 3rd again shortened and far slenderer than 2nd, and the last bifurcate and with 2 hairs on inner margin.

First pair of legs placed just behind the carapace and those of either side close to each other, being united with each other by a slender sternal bar. Second pair removed from 1st for some distance back and member of either side widely separated. Sternal bar distinct only for a short distance from their bases, disappearing in mid-ventral region. A long transverse bar of chitin runs across midventral surface in the region between those pairs of legs. Third legs far removed from 2nd and just in front of the middle of body and dislocated to the sides of trunk. First 2 pairs biramous, having biarticulate rami. Protopodite of 1st pair quadrate and armed with a spine on inner margin. Exopodite has joints equal in length, but 1st joint is narrower than 2nd and carries a long outer distal spine; 2nd joint possesses 3 much shorter subequal spines. First joint of endopodite unarmed and shorter than 2nd which ends in 2 subequal spines. Second legs stouter than 1st, but similar in structure as well as in relative size of joints. Protopodite with an outer distal spine instead of inner one. Exopodite furnished with an outer distal spine on 1st joint and 2 unequal terminal ones on 2nd joint, of which one is almost rudimentary. Endopodite with 2 equal apical spines, but spineless in 1st joint. Exopodite of both pairs of legs has rudimentary membraneous ridges of chitin on outer side both in 1st and 2nd joints. Third legs vestigial, represented by very minute oval lobes tipped by 2 spines and

buried within the pit of body integument. Caudal rami ovate, but slightly bulged outside at the base. They have 3 terminal spines, of which central one is longer than others, and have a solitary one on outer margin. Egg strings exceeding half the length of body and packed with uniserial eggs.

Male: Unknown.

Remarks: Although my specimens of *cernae* conform with those of the Mediterranean in the general appearance of body as well as in important points in the structure of appendages, they show some differences of minor importance as indicated in the following table:

	Mediterranean specimens	Loochoo specimens
1st antennae	3-jointed, with indistinct articulation; 1st joint with several spines and 2nd joint with 4	4-jointed, with distinct articulation; 1st joint with 2 spines and 2nd joint with 1
2nd maxillae	outer lamina with 1 spine	outer lamina with 2 spines
Protopodite of 1st legs	with outer spine	without outer spine
Exopodite of 2nd legs	with apical spines well-developed	one of apical spines rudimentary
Caudal rami	with 5 spines	with 4 spines

It may appear very astonishing that the species hitherto confined to the Mediterranean may occur in the Pacific, showing a discontiguous range of distribution. The Mediterranean specimens are the parasite of several fishes belonging to the Serranidae[8] and the Loochoo ones have also been taken from a fish of this family. In view of the fact that the members of this family are widely distributed in the world and that several of them can harbor *H. cernae* even in the Mediterranean, a wide distribution of this species appears highly probable. Since little has been known of the genus *Hatschekia* either from the Indian Ocean or from the South American Coast, an investigation of Serranidae from these regions as regards this parasite is much desirable.

Genus *Prohatschekia* Nunes-Ruivo, 1954

Prohatschekia laguncula n. sp.

(Figs. 5 & 6)

Occurrence: On the gills of *Doederleinia berycoides* (Hilgendorf) taken off Owase, December 9, 1952. 7 females and no male. The parasite clings to the gill filament with 2nd antennae, trailing body alongside with it and toward its free end.

Holotype: Female. Body relatively short and stumpy, 2.13 long, carapace 0.40×0.55, trunk 1.58 long, width in 1st segment 0.50, same in 2nd segment 0.72, same in genital segment 0.83, caudal segment 0.15×0.17, egg strings 1.95 long (all in mm.). Color in alcohol whitish.

Carapace somewhat depressed dorsiventrally, 1/5 as long as body and wider than long. It has broad, reentrant frontal margin, well-round sides and is produced in the rear into a short narrowed neck to join with trunk, from which it is distinctly bordered. Trunk bottle-shaped, narrowing forward and with first 2 segments well-defined by deep lateral indentations. Lateral parts of those segments more or less turned ventrally so as to continue to the bases of legs without distinct demarcation. First segment narrower than carapace, but 2nd segment somewhat wider. Succeeding region of trunk enlarged into an ellipsoidal form, equally swollen on all sides, and inserted forward to 2nd segment by a narrowed neck. It occupies more than 2/3 of body length and is wider than carapace for a half time. Caudal end evenly round, but produced on the midline into

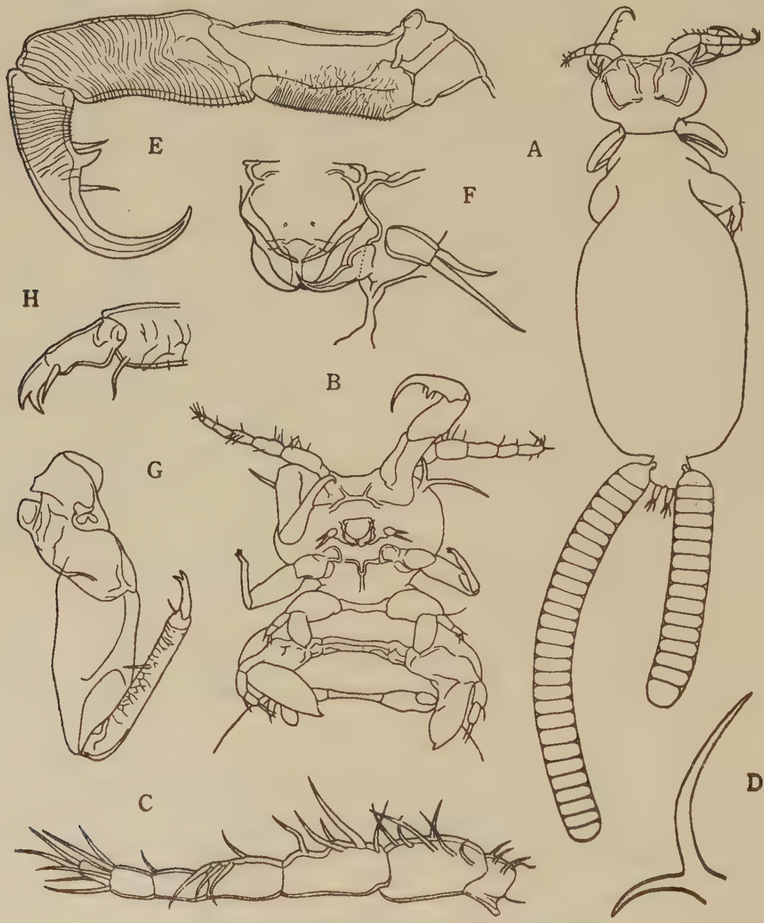

Fig. 5. *Prohatschekia laguncula* n. sp., female.

A, dorsal view; B, anterior portion of body, ventral view; C, 1st antenna; D, accessory appendage at the base of 1st antenna; E, 2nd antenna; F, maxilla and oral tube; G, maxilliped; H, apical part of same. A ×27, B ×47, C–E, G ×120, F ×170, H ×340.

a small spheroidal bulge, on whose dorsal face egg strings are attached. Abdomen entirely absorbed by this bulge, caudal rami attaching to its posterior side.

First antennae relatively well-developed, protruding laterally far beyond cephalic margin and composed of 7 joints. First joint short, 2nd much longer and followed by ones successively shortening distally; first 5 joints fringed by stiff spines along anterior border, while 6th with terminal spines circumscribing the base of 7th, which ends in 2 spines. Just outside each of 1st antennae there is a narrow filiform, bifurcate lamina which may probably represent 1st maxilla. Second antennae powerful, prehensile and consisting of 3 prolonged joints, between distal 2 of which geniculation intervenes. First joint flexed near base and with a series of fine, closely disposed, parallel ridges on inner side. Second joint straight, subequal to 1st in length and traversed by similar but sparser ridges all over the surface. Third joint strongly curved like a hook, sharply pointed, reinforced by a short conical process on inner side near base and bearing a stiff hair just proximally as well as distally to the process. Mouth tube broad, blunt at tip. Second maxillae just outside the tube and consisting of 2 quadrangular laminae; outer lamina directed outward and surmounted with 2 unequal spinules, whereas inner lamina turned inward and with a broader curved spinule overhanging mouth tube. Maxillipeds geniculate, feeble and 4-jointed. First 2 joints broad, but succeeding 2 much slenderer and hardly reaching 1st joint. Third joint provided with 2 feeble spinules, one at the end and the other at about the center, and covered with irregularly anastomosing ridges. Fourth joint ends in sharp bifurcate tip, behind which it carries a spinule.

Three pairs of legs present, all biramous. First 2 pairs located on ventral side of 2 free segments and 3rd at anterior end of fused trunk; all equally separated from one another. Second pair largest of all, 3rd smallest and each of them made up of broad lamellar protopodite, similarly lamellar, 1-jointed endopodite and much narrower rod-like, 2-jointed exopodite. First legs with a longer outer and a shorter inner spines on protopodite close to the bases of rami. Endopodite bears at its round apex a short conical ungulus and 2 feeble unequal spines just inside. Exopodite only slightly shorter than endopodite and furnished with an outer distal spine on 1st joint and with 3 stouter, terminal and 3 feebler, internal spines on 2nd joint. Second legs with external spine of protopodite much feebler than in preceding legs and without internal one. Endopodite twice as long as exopodite, more or less triangular and simply ending in ungulus; inner margin with very tiny hairs. Exopodite as in previous legs in the disposition of spines save that terminal spines are 2 in number instead of 3. Third legs with outer spine of protopodite longer than that of 2nd and without inner one. Endopodite longer than exopodite and armed only with a rudimentary claw. Exopodite has a longer outer and 2 shorter inner spines at apex; outer spine on 1st joint very

stout, longer than any of corresponding ones of other legs. Spines on the legs all non-plumose. Endopodite covered by a parallel series of narrow, transverse, membraneous ridges on anterior face in all legs. Similar ridges present on protopodite of 2nd legs also. Caudal rami oblong ovate, terminating in 3 spines besides bearing 2 and 1 feebler spines respectively on outer and inner borders. Egg tubes shorter than body and packed with uniserial eggs.

Male: Unknown.

Remarks: *Prohatschekia* has been defined by Nunes-Ruivo, who erected the genus, as to have 3 pairs of biramous legs armed with plumose spines. Although the present species goes beyond the confines of the genus in having simple spines, the presence of 3 pairs of legs points to the desirability of including

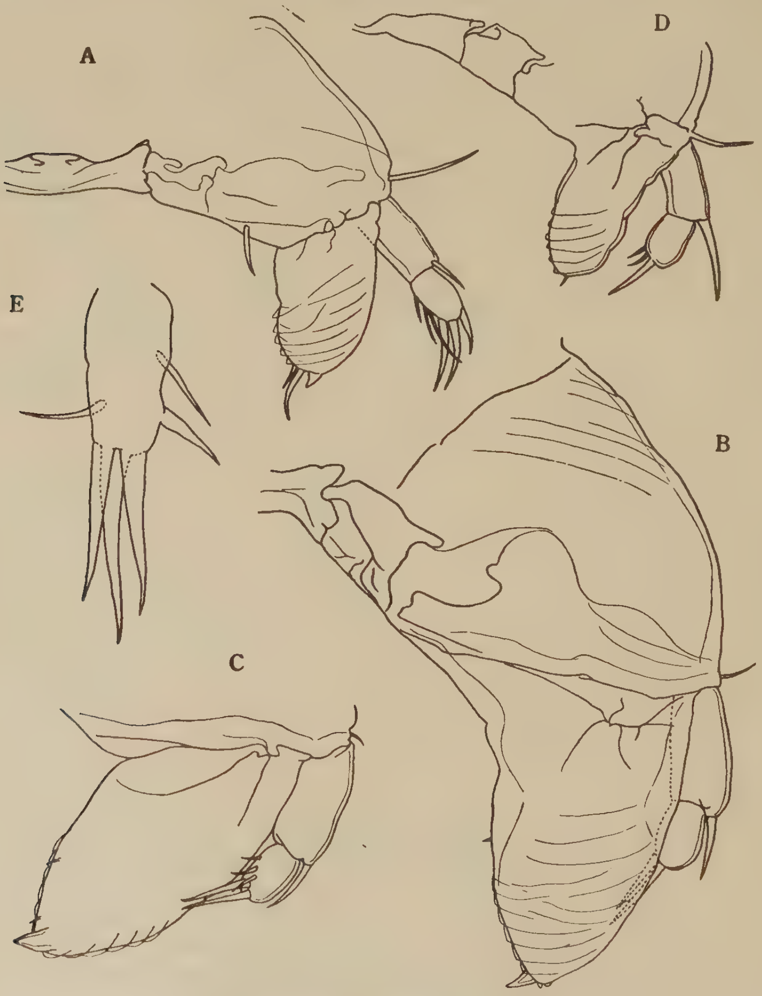

Fig. 6. *Prohatschekia laguncula* n. sp., female.
A, 1st leg; B, 2nd leg; C, 2 rami of same, posterior face; D, 3rd leg; E, caudal ramus. A–D ×170, E ×340.

it in this genus. The spines of the known species of *Prohatschekia* [*cremouni* NUNES-RUIVO[8] and *sebastici* (YAMAGUTI)[15]] are rather sparsely fringed with very short pinnules and such a rudimentary pinnation does not appear to be worthy of separating the genus from *Hatschekia*. But the presence of 3rd legs may be considered enough to warrant the genus, since in none of the species of *Hatschekia* except *H. awatati* YAMAGUTI[15] the 3rd legs are developed into biramous appendages, these being either entirely absent, or retained, at most, in the condition of mere stumps of body integument. This fact apparently justifies the assignement of the present species to *Prohatschekia*. In this connection it may be well to point out that *awatati*, is also to be referred to this genus.

The new species may be distinguished from the known ones of the genus, including *awatati*, for the first ground, by the distinctness of the first 2 segments. It has the trunk relatively longer and slenderer than in other forms and possesses a caudal bulge. The latter structure does not correspond merely to the abdomen, but to this plus a part of genital segment, for the egg tubes are attached to the dorsal side, Bifurcate appendages present just outside the 1st antennae appear to be comparable with the ones found on similar places in some forms of *Hatschekia*. They are represented, for example, by knob-like processes in *H. labracis* VAN BENEDEN[10] and by simple spiniform structures in *hippoglossi* (KRÖYER)[10,13] and *mulli* (VAN BENEDEN)[2,10]. It is probable that they are the 1st maxillae dislocated in front of the 2nd antennae, but their exact nature is not certain.

Genus *Pseudocongericola* YÜ, 1933

Pseudocongericola chefoonensis YÜ, 1933

(Fig. 7)

YÜ 1933, p. 131, Pl. 5, figs. 3 & 4, Pl. 6, figs. 1–4; YAGUTI 1939, p. 473, Pl. 28, fig. 138.

YAMAGUTI has already recorded this species from our waters, but he has not gone beyond giving the measurements and the figure of toal view. As the present specimens show an appearance different from those either of YÜ, or of YAMAGUTI, a new description has been prepared.

Occurrence: On the gills of *Muraenesox cinereus* (FORSKAL). The parasite attaches to the gill filament directing the body toward free end of the filament, but not always so. 12 females, no male.

Distribution: China and Japan.

Female: Body elongate cylindrical, neither depressed, nor compressed, 2.49 long, carapace 0.20×0.40, 1st segment 0.23×0.49, 2nd 0.29×0.52, genital segment 1.77×0.66, egg strings 2.43 long (all in mm.). Color white, but covered with

black pigment spots all over the surface, opaque; egg strings whitish to yellowish.

Head coalesced with 1st thoracic segment so as to make a somewhat depressed, transversely prolate ovoidal cephalothorax. It is twice as wide as long, slightly protruding in front on the median and bordered from 2nd segment by deep lateral notches. Second and 3rd segments well-defined by similar notches,

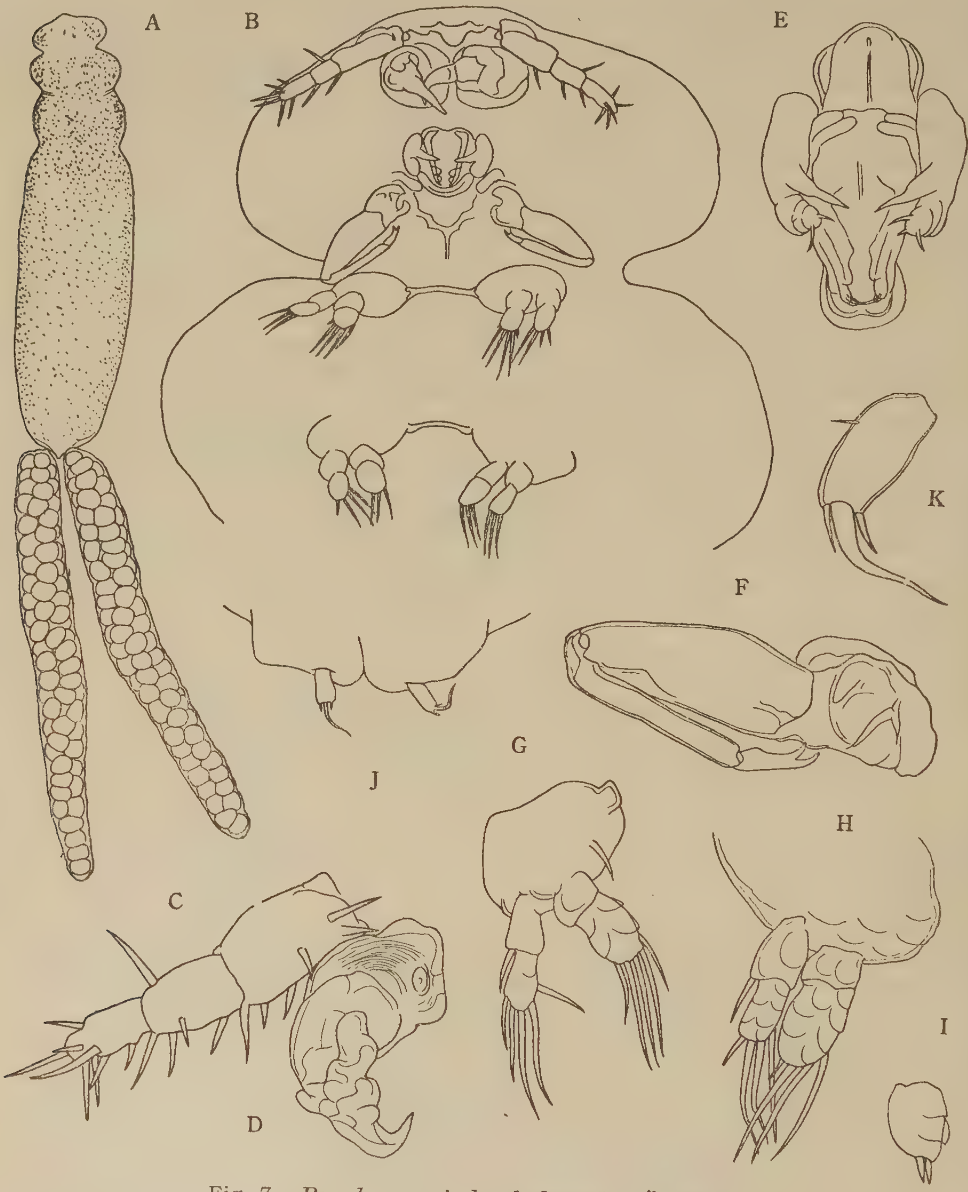

Fig. 7. *Pseudocongericola chefoonesis* Yü, female.

A, dorsal view; B, anterior portion of body, ventral view; C, 1st antenna; D, 2nd antenna; E, mouth tube with maxillae; F, maxilliped; G, 1st leg; H, 2nd leg; I, 3rd leg; J, abdomen with caudal rami; K, caudal ramus. A ×23, B, J ×170, C, D ×375, E, F, I, K ×490, G, H ×340.

but with lines of border largely obliterated. They are a trifle longer and wider than head, equal in width each other, though 3rd is longer than 2nd, and both have well round sides. Succeeding region prolonged to form a sausage-shaped trunk occupying more than 2/3 of the entire length. It is even on the sides and ends in a narrow point where it bears rudimentary abdomen which is represented by an insignificant transverse ridge.

First antennae short, 3-jointed, locating on ventral surface of carapace just behind frontal margin close to midline and invisible from above. Each joint armed with stiff spines on posterior border; 2nd joint with an additional spine on anterior border and 3rd encircled by subterminal spines besides terminal ones. Second antennae short, feeble and hook-like, composed of broad base and well-curved claw, which is nodular near base and sharply pointed at tip. Mouth tube conical, blunt at apex. Maxillae close to either side of mouth tube and represented by rod-like ridges directing backward and having bifurcate end; inner lamina narrow, acuminate, overhanging mouth tube and outer lamina blunt, indistinctly jointed, and ending in 2 or 3 tiny divergent spinules. Maxillipeds feeble, consisting of 2 wider basal and 2 much slenderer apical joints; 2nd joint longest of all and 4th shortest, with bifid tip and reaching beyond the base of 2nd joint.

First pair of legs placed at posterior end of carapace and 2nd pair at the centre of following segment; the former slightly smaller than the latter in size. Both of them consist of more or less ovate, lamellar protopodite and narrow 2-jointed, subequal rami. Apical joint longer than basal joint in both rami and in both pairs. Protopodites of both sides close to midline in either pair and connected together by narrow transverse sternal bar. First legs have an inner spine on protopodite which is absent from 2nd. Endopodite of 1st legs provided with 5 terminal spines; exopodite with a single spine at outer distal angle of basal joint and 4 terminal and 1 inner, subterminal ones on apical joint. Both rami of 2nd legs tipped by 3 longer and 1 much shorter outer spines and endopodite bearing an outer distal spine on basal joint. In both pairs of legs, rami as well as protopodite more or less covered by scale-like ridges of integument. Third legs close to the sides of segment, and represented by tiny unjointed laminae tipped by 2 vestigial spines and with surface scales. Caudal rami very small, oblong, ending in a relatively long spine, which is associated with a much shorter spine on each side; they bear, in addition, a thin short solitary hair on the outside. Egg tubes filiform, about as long as body, trailing backward and packed with multiserial round eggs.

Remarks: *Pseudocongericola* bears a close resemblance to *Hatschekia*. To the differences between them enumerated by the original author, it may be added that *Pseudocongericola* possesses egg strings enclosing multiserial round eggs instead of uniserial flattened ones. The present specimens show a somewhat

slenderer body than those figured by Yü or by Yamaguti and have the head relatively smaller and more deeply constricted from the rest of body. Pigmentation on the surface of body has not been alluded by either of the authors.

References

1. van Benden, P., 1853. Note sur un nouveau genre de crustacé parasite (*Pagodina*). Acad. Roy. Belg., Vol. 20, pp. 482–487, Pl. 1.
2. Brian, A., 1906. Copepodi parassiti dei pesci d'Italia, pp. 1–187, Pls. 1–21, Genova.
3. ———, 1914. Nuove aggiunte al catalogo dei copepodi parassiti dei viventi nel mare Ligustico. Atti. Soc. Ligustica Sci. Nat. et Geograph., Vol. 25, pp. 133–137.
4. Capart, A., 1953. Quelques copépodes parasites de poissons marins de la région de Dakar. Bull. Inst. Fr. Afriq. Noire, ser. A, Vol. 15, pp. 647–671.
5. Causey, D., 1953. Parasitic Copepoda of Texas coastal fishes. Publ. Inst. Mar. Sci., Vol. 3, pp. 7–16.
6. Delamare-Deboutteville, C. and L. Nunes-Ruivo, 1954. Copépodes parasites des poissons Méditerranéens (3° ser.) (I). Vie et Milieu, Vol. 4, pp. 201–217.
7. Heller, C., 1865. Reise der Oesterreichischen Fregatte Novara um die Erde. Zool. T., Vol. 2, Crustaceen, pp. 1–280, Pls. 1–25, Wien.
8. Nunes-Ruivo, L., 1954. Parasites des poissons de mer ouest-africains récoltés par M. J. Cadenat. III, Copépodes (2° note); genre *Prohatschekia* n. gen. et *Hatschekia* Poche. Bull. Inst. Fr. Afriq. Noire, ser. A, Vol. 16, pp. 479–505.
9. Pearse, A. S., 1951. Parasitic Crustacea from Bimini, Bahamas. Proc. U. S. Nat. Mus., Vol. 101, pp. 341–372.
10. Scott, T. and A. Scott, 1913. The British parasitic Copepoda, 2 Vols., pp. 1–252, Pls. A, B, 1–72, London.
11. Wilson, C. B., 1913. Crustacean parasites of West Indian fishes and land crabs, with descriptions of new genera and species. Proc. U. S. Nat. Mus., Vol. 44, pp. 187–277, Pls. 18–53.
12. ———, 1922. North American parasitic copepods belonging to the family Dichelesthiidae. Ibid., Vol. 60, pp. 1–95, Pls. 1–13.
13. ———, 1932. The copepods of the Woods Hole Region, Massachusetts. U. S. Nat. Mus. Bull. 188, pp. 1–635, Pls. 1–41.
14. ———, 1935. The parasitic copepods from the Dry Tortugas. Pap. Tortugas Lab., Vol. 29, pp. 329–347, Pls. 1–6.
15. Yamaguti, S., 1939. Parasitic copepods from fishes of Japan, Pt. 5, Caligoida, III. Vol. Jubil. Prof. S. Yoshida, Vol. 2, pp. 443–487, Pls. 14–33.
16. Yü, S. C., 1933. Chinese parasitic copepods collected by H. W. Wu, with descriptions of new genera and species. Bull. Fan Mem. Inst. Biol., Vol. 4, pp. 129–133, Pls. 1–7.

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Copepods Parasitic on Japanese Fishes

16. Bomolochidae and Taeniacanthidae

(*With 6 Text-figures*)

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The Cyclopoida contain 3 families parasitic on the fishes, the Ergasilidae, Bomolochidae and Taeniacanthidae, all of which retain much of the copepod structure. The Ergasilidae are for the most part fresh-water forms, a few infesting the fishes which make a return trip from the river to the sea, or inhabit estuaries. In this family, the 2nd antennae are developed into powerful clasping organs with which the parasites seize the gill filaments of host. The Bomolochidae and Taeniacanthidae are both the parasites of marine fishes and are nearly related each other in the constitution of the 2nd antennae which are not so well-developed as in the Ergasilidae. Although these appendages are prehensile and plentifully supplied with armatures, they are rather feeble and not adapted for clasping the gills, since they are geniculate outward instead of inward, namely in a direction opposite to that which is prevalent in the other family.

A large number of species belonging to those families have been recorded from our waters by YAMAGUTI (1936, '39, '54), in addition to the one reported by WILSON (1922). The present arcticle adds to these three more species, all new to science, of which two belong to the Bomolochidae while the rest to the Taeniacanthidae. The type specimens will be lodged in the Prefectural University of Mie hereafter.

Family Bomolochidae

Genus *Bomolochus* Nordmann, 1832

Bomolochus gibber n. sp.

(Figs. 1 and 2)

Occurrence: On *Tylosus giganteus* (T. & S.) taken at Owase, Mie Prefecture, November 19, 1953. 17 females, no male. Each of the parasites attaches to the inner surface of operculum close to its dorso-posterior corner.

Female: Holotype. Anterior region of body expanded and swollen dorsally, with 3rd thoracic segment overlapping succeeding ones; from 4th segment backward body much narrowed and cylindrical. Entire length 2.28, carapace 0.77×1.43, 2nd thoracic segment 0.29×0.94, 3rd 0.71×1.02, genital segment 0.24×0.37, abdomen 0.37 long, 1st segment 0.18×0.25, 2nd 0.10×0.23, 3rd 0.10×0.20, egg tubes

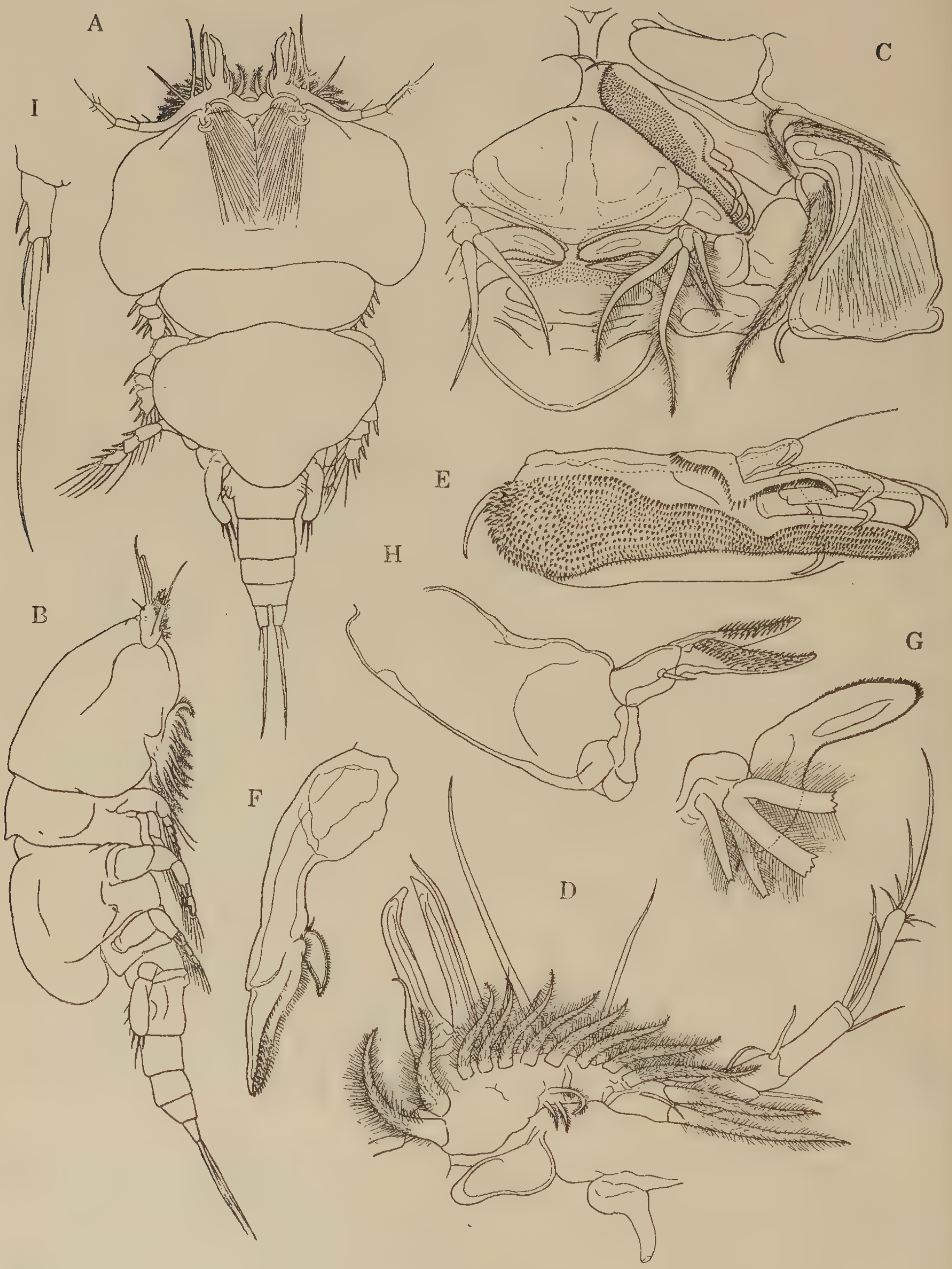

Fig. 1. *Bomolochus gibber* n. sp., female. A, dorsal view; B, lateral view; C, 2nd antenna, mouth parts and 2nd maxilliped; D, 1st antenna and 1st maxilla; E, 2nd antenna; F, mandible (left); G, 2nd maxilla (right); H, 1st maxilliped (right); I, caudal ramus. A, B ×30.5, C ×155, D ×110, E H ×305, I ×75.

0.85×0.35 (all in mm.). Color of body and egg tubes white.

Carapace occupying 1/3 of entire length, twice as wide as long, convex dorsally and concave ventrally. It is nearly a semicircle in shape, having widely round anterior and straight posterior borders, notched in front on the median and undulated on sides owing to the development of round lobe at each postero-lateral angle. Second thoracic segment 2/3 as wide and 1/4 as long as carapace, transversely linear; sides narrowly round, converging backward and retreating from general outline of body. Third segment wider and far longer than 2nd, but still narrower than carapace, to which it is nearly equal in length. It is roughly triangular and produced back into a round lobe overlapping 4th and 5th segments. Sides are well round, inclining toward each other and continue to the medio-posterior lobe past a slight excavation. Fourth and 5th segments abruptly narrowed, cylindrical, similar in length and width to each other and invisible from above. Genital segment longer than 5th, but slightly narrower, and with a pair of lateral bulges, to which the egg strings are attached. Abdomen somewhat shorter than foregoing 3 segments combined together, gradually tapering backward and 3-segmented. First segment longer than others which are equal. First and 2nd segments quadrate, but last segment trapezoid narrowing caudad.

First antennae well-developed, curving forward in apical part and made up of 3-jointed peduncle and 4-jointed flagellum. Peduncular joints partially fused together and fringed along anterior border by stout, more or less flexible, plumose spines which are heavily covered with multiserial hairs. A few similar, but much feebler spines present on ventral surface of 1st joint close to the end. On anterior margin near the base and dorsally to the row of plumose spines, this joint is armed with a long anteriorly projecting process, which is split from the very base into 2 flattened, spiniform, parallel lobes and is associated at the base with a longer outer and shorter inner, simple stiff spines running parallel with the process. Distally to this process and dorsally to plumose spines, the joint is furnished, further, with 2 short stiff, non-plumose spines inclining distally and with a much longer one projecting straight forward. Another similar, dorsal spine present in 2nd joint and a very short ventral one in the 3rd. Flagellar joints increase in length proximo-distally except 2nd joint which is shortest. Each of them only sparingly supplied with non-plumose spines at distal end. Second antennae small in size, 3-jointed, 1st and 3rd joints elongate, but the 2nd very short and with a single spine. Third joint folded back, produced at the apex into a finger-like blunt process and reinforced on the anterior side of this process with 7 curved, hook-like spines, one of which is thickly pectinate on hind border. Extending from the base to the terminal process and covering more than posterior half of surface, the joint is roughened with rows of fine spinules; an isolated, curved row of spinules runs across antero-distal part of joint so as

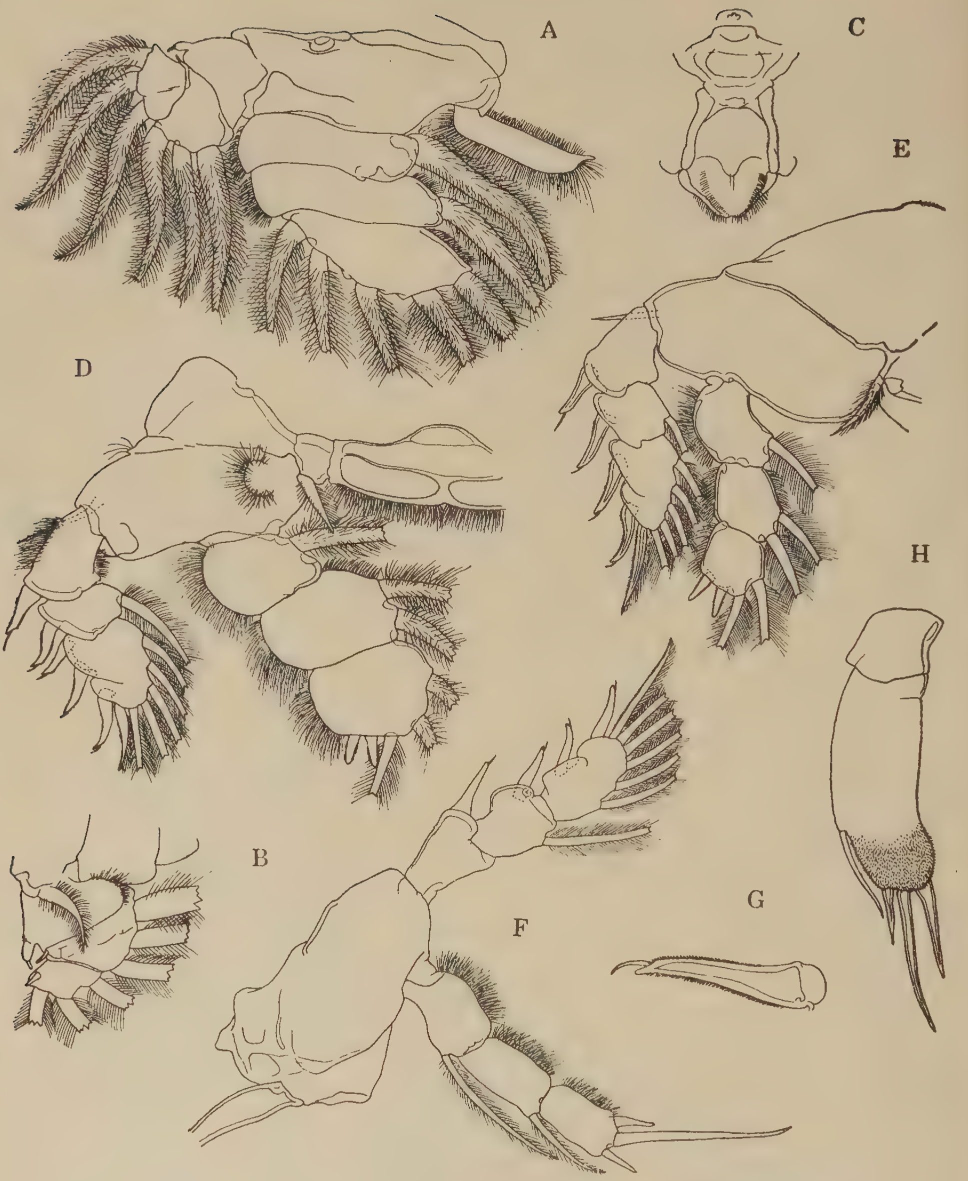

Fig. 2. *Bomolochus gibber* n. sp., female. A, 1st leg; B, exopodite of same, posterior surface; C, sternal plate of 1st legs; D, 2nd leg; E, 3rd leg; F, 4th leg; G, outer spine on exopodite of 4th leg; H, 5th leg. A–F, H ×108, G ×305.

to reach the base of the pectinate spine, with whose pectination those are continuous. Labrum in the shape of a scallop. Mandibles slender and with relatively large acuminating blade, which is indistinctly jointed at base and spinulose both on surface and on margins. They bear at the base of the blade much smaller foliaceous gnathobasis marginated with pectination. First maxillae dislocated far forward close to the bases of 1st antennae, hook-like and accompanying

a triangular process of chitin just internally. Second maxillae bear at the base 2 longer and 2 shorter, divergent plumose spines and possess cutting blade which is apically round linguiform and circumscribed by fine spinules along nearly whole margin. First maxillipeds have basal joint stout and long; 2nd joint is much narrowed and shortened, bearing a single short spine and surmounted by 2 attenuated blades, which resemble each other in size and are heavily spinulose on anterior face. Labium a mere bulge of sternum, finely granulated in its anterior part. Second maxillipeds displaced to the sides of other mouth parts, 2-jointed. Basal joint is broad, triangular in shape and carries at its narrowed fore end a stout terminal claw, which is curved like a comma without issuing any branch and is folded back over the surface of basal joint. At inner posterior angle, basal joint carries a short curved spine and, at anterior angle close to the base of claw, 3 far stouter spines covered with multiserial hairs; one of these is very long extending backward beyond the joint, whereas the others are much shorter projecting forward and outward respectively.

First 4 pairs of legs biramous, consisting of broadly lamellar protopodite and 3-jointed rami, while 5th pair uniramous and 2-jointed. First pair differ in structure from succeeding pairs. In this pair, each joint of endopodite lamellar and strongly widened laterally, but exopodite shorter, narrower and somewhat crooked, being composed of triangular joints, and both the rami fringed by stout long spines with multiserial barbs; protopodite unjointed, much wider than long and united with its fellow of opposite side by a sternal plate of peculiar shape. Joints of endopodite of 2nd pair broader than in following pairs, more or less resembling those of 1st pair and furnished with similar plumose spines, whereas exopodite narrower, agreeing with the same ramus of following pairs in the configuration of joints as well as in their armatures. Third and 4th pairs with the 2 rami alike in shape and size and armed with pinnate spines which are hairy only on 2 opposite borders. Their exopodite, together with that of 2nd pair, has a lunar-shaped lobe on first 2 joints on outer margin, but the last joint always bears 2 of such lobes, which apparently indicate that the joint has resulted from the fusion of 2 joints. Protopodite 2-jointed in 2nd and 3rd legs, but unjointed in 4th and that of 2nd legs provided on ventral surface close to inner side with an oval lobe circumscribed with short hairs. A narrow sternal bar combines protopodites of 2 sides so as to form a continuous basal apron in all pairs. Fifth legs consist of very short base and prolonged apical joint which is closely covered with fine spinules in terminal area besides bearing ordinary spines. Disposition of spines and other armatures present in each of 5 pairs of legs is shown in the Table 1.

Barbed spines on inner margin of protopodite of 1st legs is very peculiar. It is a narrow flattened bar having uniform width throughout, except narrowly

Table I. Arrangement of spines and other armatures in 5 pairs of legs of *Bomolochus gibber* n. sp.*

Leg	Border	Sternal plate	Protopodite		Exopodite			Endopodite		
			I	II	I	II	III	I	II	III
I	outer	c	1p		1rh	1rh	1rh	c	c	5P′
	inner		1P″		c	3P′	3P′	1P′	c, 1P′	c
II	outer	c	cc	1H	c, 1H′	1H′	3H′, 1Q	c	c	c, 2h
	inner		1p	ciliated lobe	c	1P	5P	1P′	c, 2P′	2P′, 1P
III	outer			1h	1H′	1H′	2H′, 1Q	c	c	c, 2h
	inner		1p			1P	5P	1P	c, 2P	2P
IV	outer				1H′	1H′	2H′, 1Q	c	c	c
	inner					1P	5P	1P	1P	1h, 1H, 1h
V	outer				1h, cc					
	inner				1h, 1H, 1h					

pointed apex, and is fringed by dense hairs along margins. Outer spine on 1st joint of exopodite has thickened base. Outer spines on exopodite of 2nd to 4th legs are also peculiar to the species. They are finely pectinate on 2 opposite borders and end in an acuminate apex, behind which a short filiform prolongation arises to extend farther. Two short apical spines on endopodite of 2nd and 3rd legs also pectinate, but blunt at apex. Of terminal spines on exopodite of 4th legs, central one surpassing others in length and almost as long as plumose spines on endopodite. These spines as well as the same of 5th legs very finely pectinate.

Caudal rami rod-shaped, short, but ending in an elongate spine and carrying 4 much shorter additional hairs, disposed 1 at inner distal angle and the rest along outer border. Egg sacs wide, about half as long as body and with eggs multiseriate. They are liable to be detached from the body.

Male: Unknown.

Remarks: The holotype is the largest specimen out of the collection. In most of the cases, the 3rd segment is not so strongly produced as in the type, and is evenly rounded on posterior side, though overlapping succeeding segments. In this point, the present form nearly allies to the group of species which were formerly included in the genus *Artacolax* Wilson (1911). This genus, however,

* Abbreviations used in the Tables I–III:—
c, row of hairs; cc, area covered with hairs; H, long simple spine; h, short simple spine; H′, spine peculiar to respective species; P, long spine doubly edged with hairs; p, short spine doubly edged with hairs; P′, long spine covered with multiserial hairs; P″, hairy spine peculiar to respective species; Q, spine hairy on one side, non-hairy on the other side; rh, rudimentary spine. Roman numerals represent the numerical orders of legs, or of joints and Arabian ones the number of spines, or other armatures present on each of them.

was subject to the criticism of subsequent authors and was reduced to the rank of subgenus of *Bomolochus* by YAMAGUTI (1939). The status of *Artacolax* was recently discussed more fully by STOCK (1953), who suggested that the name must be sunk in the synonymy of *Bomolochus* and ought to be rejected. The present species may be recognized from the known forms formerly included in *Artacolax* by that the 3rd segment of the body is wider and longer than the 2nd segment.

Pseudobomolochus is another subgenus of *Bomolochus* established by YAMAGUTI (1939) on the basis of the sole character that it possesses a tripartite process on the 1st antennae. As he included WILSON's *Artacolax saetiger*[8,9,12] in his subgenus on account of this character, he appears to have laid greater stress on this point rather than the imbrication of 4th segment over succeeding segments. But he was somewhat conflicting, since he referred later (1953) his species *cypseluri* to *Artacolax*, which he had relegated to the rank of subgenus (1939), in spite of the presence of such a process on the 1st antennae. His species shows the character of *Artacolax* on one hand while that of *Pseudobomolochus* on the other hand exactly in the same way as *saetiger* does. *B. gibber* also shows the overlapping of segments while having the similar process on the 1st antennae. It is, therefore, problematical to me whether *Pseudobomolochus* may be well defined and whether the presence or absence of such a process may deserve a subgeneric separation.

Bomolochus tumidus n. sp.

(Figs. 3 and 4)

Occurrence: On *Cololabis saira* (BREVOORT) taken off Owase, Mie Prefecture, November 18, 1953. 33 females, no male. The parasites attach themselves either to the inner surface of operculum or to the gills.

Female: Holotype. Closely resembling *gibber* in general configuration as well as in details of appendages. Body 1.70 long, carapace 0.64×1.20, 2nd thoracic segment 0.25×0.97, 3rd 0.34×0.67, 5th plus genital segment 0.33×0.34, abdomen 0.28 long, 1st segment 0.11×0.23, 2nd 0.07×0.21, 3rd 0.10×0.18, egg tubes 1.12×0.41 (all in mm.). Color rather pale brown, transparent, egg tubes white.

Carapace longer than 1/3 of body, twice as wide as long, wider posteriorly than anteriorly and semicircular in outline. It is swollen dorsally and has narrow, truncate front and evenly curved sides, which meet with nearly straight hind border past a well round corner. A pair of divergent, submarginal ridges extend from the front backward, ending some distance in front of hind margin. Thoracic segments successively narrower from before backward. Second segment

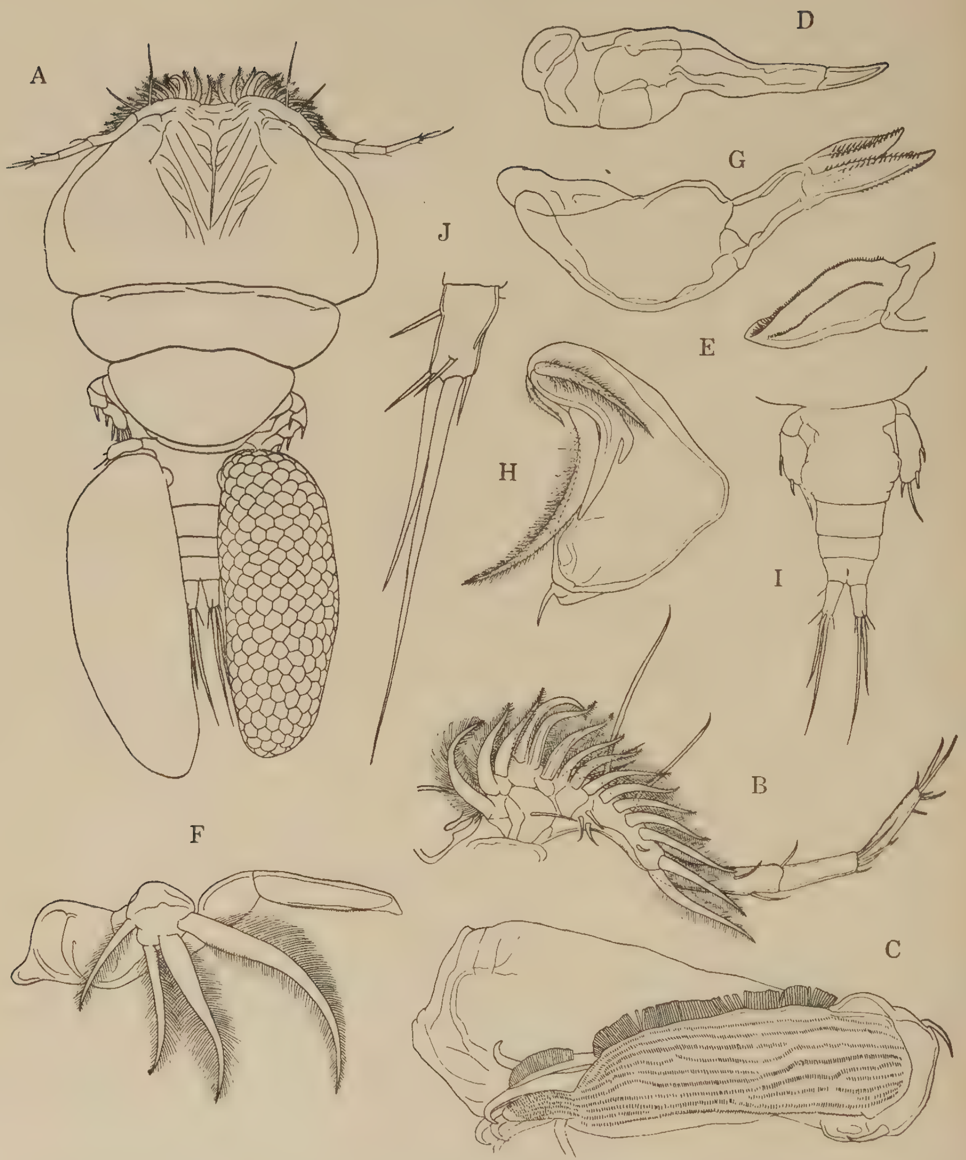

Fig. 3. *Bomolochus tumidus* n. sp., female. A, dorsal view; B, 1st antenna; C, 2nd antenna; D, mandible; E, tip of same; F, 2nd maxilla; G, 1st maxilliped; H, 2nd maxilliped; I, caudal end of body, with egg sacs removed, dorsal view; J, caudal ramus. A, I ×36.5, B ×75, C, D, F, G ×305, E ×440, H ×160, J ×110.

4/5 as wide as carapace and a quarter as long, with both fore and hind borders insensibly arched forward and with sides inclining inward. Third segment again narrower, about 2/3 as wide as 2nd, but exceeding the length of the latter for a half time. It is semicircular and gracefully curved posteriorly, overlapping larger part of 4th segment which is invisible from above except a small posterior portion. Fourth segment somewhat abruptly narrowed. Fifth segment further narrower and entirely fused with genital segment, slight lateral constrictions

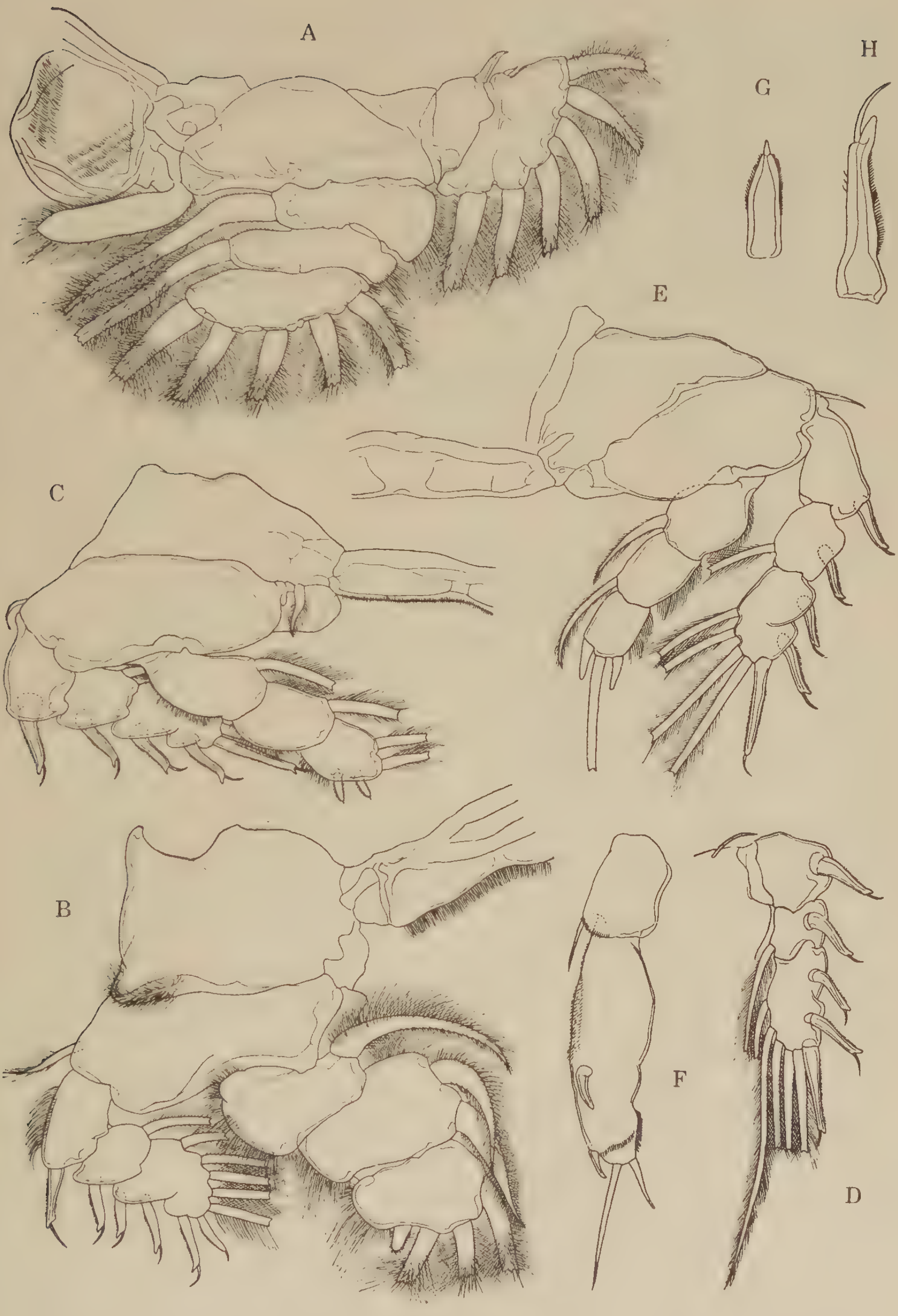

Fig. 4. *Bomolochus tumidus* n. sp., female. A, 1st leg; B, 2nd leg; C, 3rd leg; D, exopodite of same, posterior surface; E, 4th leg; F, 5th leg; G, outer spine on endopodite of 3rd leg; H, outer spine on exopodite of same. A–F ×122, G, H ×440.

indicating the boundary of the two. Genital segment as wide as 5th, but far longer, and more or less irregular on the sides on account of genital ridges. Abdomen a trifle shorter and narrower than preceding fused segment, gradually attenuating backward and composed of 3 segments. First segment longest, 3rd coming next and trapezoid in shape unlike others which are quadrangular.

First antennae long, projecting freely beyond the sides of carapace and more or less flexed forward; peduncle broad, unjointed, having constituent joints entirely fused together, while flagellum distinctly divided into 3 subequal, slender joints. Peduncle fringed along its anterior margin with a row of flattened, flexible, plumose spines, of which 4th from the proximal end is non-plumose. Dorsally to this row, it is armed with 2 slenderer, stiff spines inclining distally and 2 far longer similar ones projecting forward, and scattered by a few very short ones on ventral surface. Flagellar joints sparingly supplied with short simple, terminal or subterminal spines. Second antennae resemble those of *gibber* in size and structure. Second joint has a short solitary hair on anterior as well as on posterior sides. Third joint is produced at the apex into finger-like, blunt process and carries 7 curved apical spines, of which the anteriormost is fringed by a row of rather long spinules closely arranged like the teeth of a comb. The joint is also marginated by a similar comb-like row of spinules along the anterior border almost from end to end and is covered over whole ventral surface by longitudinal lines, each of which is made up of very short transverse ridges closely standing one behind the other; these lines invade the apical process as far as its tip. Labrum and labium as in *gibber*. Mandibles with terminal blade distinctly jointed, but without gnathobasis; blade short, tapering to the tip and finely pectinate on margin besides with more internal pectinate line. First maxillae absent. Second maxillae with basal joint attenuated distally and armed with 4 divergent plumose spines, of which inner 2 are stouter than others; terminal blade a very slender rod ending in blunt tip, distinctly jointed basally and feebly pectinate on posterior border. First maxillipeds bifurcate, with indistinct articulation; 2 blades unequal in size, but equally pointed, with rows of spinules on anterior margin and a somewhat feebler row on posterior margin. Second maxillipeds placed outside the preceding oral appendages and composed of broad base and stout terminal claw folded back over it. Base triangular, broadening backward, but concave on inner margin and with a short spinule at inner posterior angle and 3 hairy spines close to the attachment of claw. These spines are surrounded by multiserial hairs and graded in length as well as in thickness; longest and thickest one arises behind the claw to direct postero-internally, while rest ones locate just in front of claw and direct posteriorly. Claw is bent inward at the centre, where it bears a short external branch projecting parallel with it.

All pairs of legs very similar to those of *gibber* in structure. First 4 pairs biramous and made up of 2-jointed lamellar protopodite and 3-jointed rami except 1st pair, in which apical 2 joints of exopodite are fused together and protopodite is unjointed. Endopodites of first 2 pairs expanded into broad lamellae and together with exopodite of 1st pair, furnished with thick spines surrounded by multiserial pinnules. Exopodite of 2nd pair and both rami of succeeding 2 pairs narrower, subequal in size to one another and carrying plumose spines doubly edged with hairs. Exopodite of those pairs has lunar-shaped lobe in first 2 joints on outer side, but has 2 of such in last joint. Sternal plate a narrow transverse bar in 2nd to 4th pairs, but a nearly quadrangular lamella in 1st pair, which is broader than that of *gibber* and is provided with 3 oblique rows of tiny hairs on the surface on each side. Fifth legs 2-jointed, consisting of short basal and much longer apical joints. Table II shows the disposition of armatures present on each pair of legs:

Table II. Arrangement of spines and other armatures in 5 pairs of legs of *Bomolochus tumidus* n. sp.

Leg	Border	Sternal plate	Protopodite		Exopodite			Endopodite		
			I	II	I	II	III	I	II	III
I	outer	cc			1h	1rh		c	c	c, 5P′
	inner		1P″			6P′		1P′	c, 1P′	c
II	outer	c	c	1p	c, 1H′	1H′	4H′	c	c	c, 1h
	inner					1P	5P	1P′	c, 2P′	3P′
III	outer	c		1h	1H′	1H′	3H′	c	c	c, 2h
	inner		1p			1P	5P	1P	c, 1P	2P
IV	outer			1h	1H′	1H′	3H′	c	c	c
	inner					1P	4P	1p	1p	1h, 1H, 1h
V	outer		1h, c		cc, 2h, c					
	inner				c, 1h, 1H					

Inner spine on protopodite of 1st legs is a flattened bar, of uniform width throughout though bluntly pointed at tip and is fringed by hairs merely along borders. Outer spines on exopodite of 2nd to 4th legs are pectinate on one side almost from base to end, but rather feeble or lacking in pectination on the other side and have narrowed tip which is associated with a short string just behind. Of apical spines on endopodite of 2nd legs, outermost is reduced to very short pectinate spine. Proximal joint of protopodite thickly hairy at outer angle in this pair of legs. Outer 2 of terminal spines on 3rd legs replaced by very short pectinate one, ending in tiny claw. Apical spines on endopodite of 4th pair without pectination; central one of them prolonged, almost equaling to

plumose ones of exopodite. Fifth legs furnished with row of short hairs on 1st joint on the outside along distal border, with similar row on ventral border of 2nd joint for a short distance back from the tip, with another row on inner surface across the apical part of joint and with several dorsal rows ranging from the base to the subterminal spine.

Caudal rami short, terete, ending in 2 long but unequal spines and bearing 4 much shorter ones, which are disposed one at inner distal angle, another on dorsal face somewhat in front and the rest 2 on inner side at the end and far forward respectively. Egg tubes 2/3 as long as body, rather broad and closely packed with eggs arranged in several rows.

Male: Unknown.

Remarks: The present species is closest to *B. decapteri* Yamaguti[10] in the general body constitution as well as in the details of appendages, but is different in the complete fusion of 5th and 6th segment and in the absence of granulated areas from the caudal end as well as from the exopodites of legs. It is also nearly allied to *gibber* described before and to other species of *Artacolax* group in that the 3rd segment overlaps the 4th almost entirely. It is distinguished from *gibber* by the 3rd segment being narrower than the 2nd, apart from the other points, and from *Bomolochus cornutus* Claus[3], *saetiger* (Wilson)[5,6], *scomberescoscis* Krφyer[6] and *cypseluri* Yamaguti[10], all belonging to that group, by the absence of tripartite process from the 1st antennae as well as by the union of the 5th and 6th segments, and from *unicirrus* Brian[1,2] and *ardeolae* (Krφyer)[6] by the latter character. In the union of these segments, the new species resembles *B.* [*Artacolax*] *palleucius* (Wilson)[9], but the 2nd and 3rd segments are distinctly separated unlike in this species.

Family Taeniacanthidae

Genus *Parataeniacanthus* YAMAGUTI 1939

Parataeniacanthus rotundiceps n. sp.

(Figs. 5 and 6)

Occurrence: On *Pseudoblennius percoides* Günther taken at Seto, Wakayama Prefecture, April 22, 1954. 7 females and 1 male were found in the deeper region of buccal cavity, on the gill filament, or on the inner surface of operculum.

Female: Holotype. Body slender, elongate, length (excluding caudal rami) 2.58, carapace 0.74×0.84, 2nd thoracic segment 0.29×0.51, 3rd 0.24×0.47, 4th 0.24×0.39, 5th 0.14×0.33, 6th (genital segment) 0.16×0.33, abdomen 0.80 long, 1st segment 0.24×0.24, 2nd 0.22×022, 3rd 0.16×0.17, 4th 0.17×0.16, egg tubes 1.47×0.31 (all in mm.). Transparent, colorless, egg tubes whitish.

Carapace convex dorsally, concave ventrally and orbicular in outline. Front

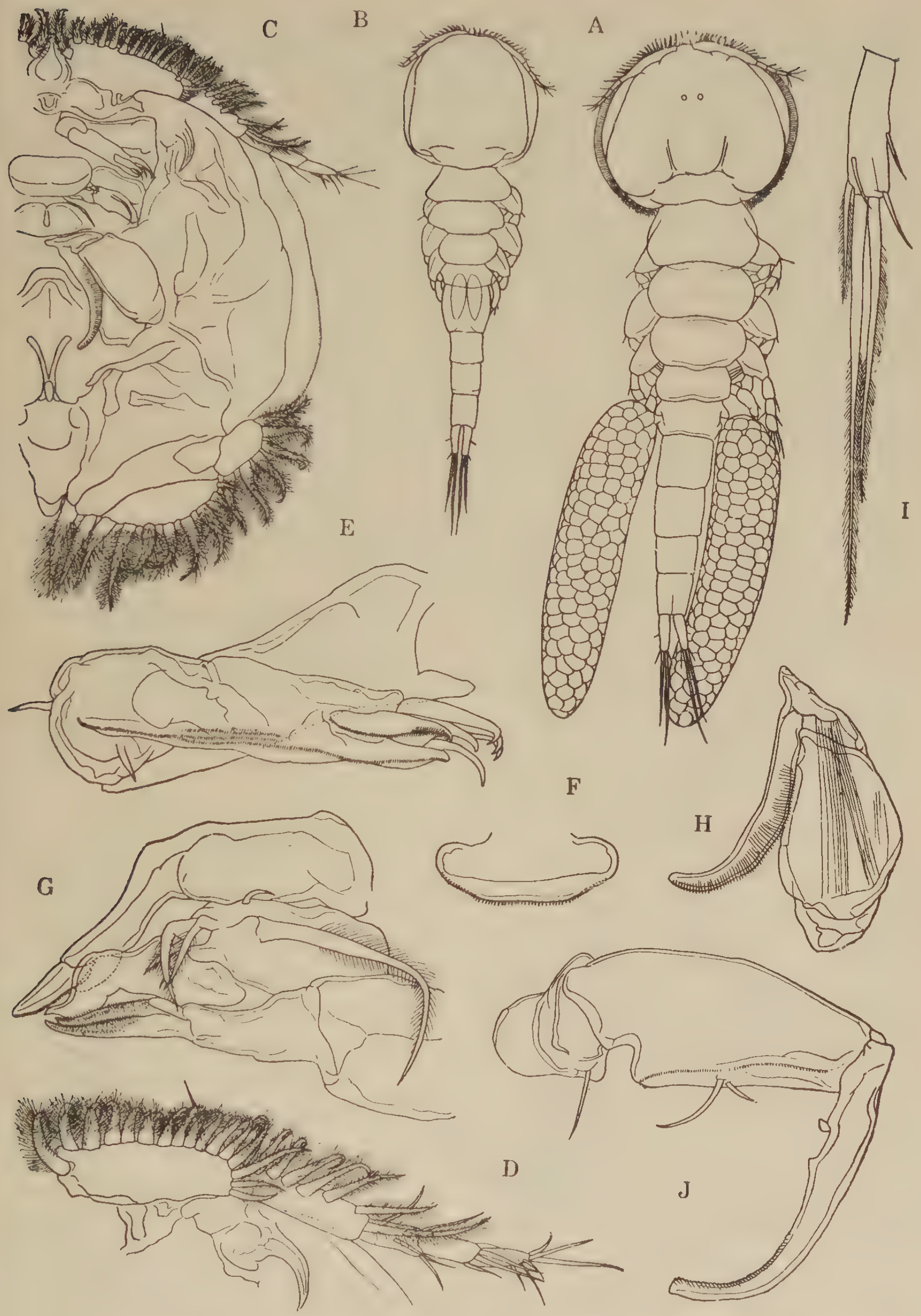

Fig. 5. *Parataeniacanthus rotundiceps* n. sp. A, female, dorsal view; B, male, dorsal view; C–I, female; C, carapace, ventral view; D, 1st antenna and 1st maxilla; E, 2nd antenna; F, labrum; G, mandible, 2nd maxilla and 1st maxilliped in situ; H, 2nd maxilliped; I, caudal ramus, ventral view; J, male, 2nd maxilliped. A ×30.5, B ×47, C ×75, D ×122, E, G, J ×305, F, H ×153, I ×108.

produced on the midline into a short small quadrate plate. On dorsal surface close to lateral margins there are a pair of posteriorly divergent ridges which separate narrow flattened lateral areas from the swollen central region. Near posterior end on each side, carapace is deeply incised forming a round lobe which overlaps the lamellar protopodite of 1st legs. A shallow furrow connects the base of lobe with its fellow of opposite side across the carapace, thus bordering 1st thoracic segment from head region more or less indistinctly. Carapace marginated by narrow membraneous flanges, which together with the pinnate spines of 1st antennae and of 1st legs form an effective adhesive disk. Eyes in front of the center of carapace, without pigmentation. Region of 1st segment short and narrow, occupying 1/5 of carapace length and reaching half of width. Thorax 2/5 as long as body. Second segment 3/5 as broad as carapace and 2/5 as long. Succeeding segments decrease in width as well as in length slightly but regularly from before backward; genital segment 2/3 of 2nd segment in length and half in width. Each segment has well-round sides and nearly straight articulating line. Fifth and 6th (genital) segments distinct from each other. Abdomen elongate cylindrical, 4/5 as long as thorax, insensibly tapering backward and 4-segmented. First segment only slightly narrower than genital segment but exceeding in length for a half time. All segments quadrangular and diminishing in size a little by little backward. Egg tubes attached to dorsal face of genital segment and exceeding caudal end. They are banana-shaped and packed with multiserial eggs.

First antennae not very long, consisting of 2-jointed peduncle and 3-jointed flagellum. Peduncular joints subequal in length, but 1st of them broader than 2nd. They are fringed along anterior border with a row of thick, dorsally curled spines closely surrounded by multiserial hairs; these invade the terminal border of joints on ventral side. First joint has a stiff, non-plumose spine near distal end dorsally to hairy ones. Flagellar joints equal in length to one another, exactly the same as 1st peduncular joint in their combined length and armed with a few stiff simple spine. Second antennae rather feeble, 3-jointed. First joint long, unarmed, but 2nd short and provided with 2 acuminate spines, one on each of anterior and posterior sides. Third joint long, folded back so as to reach the base of 1st. It is produced at the apex on posterior side into a short finger-like lobe and bears in front of it 5 hook-like spines as well as a subterminal, finely pectinate one. Posterior border of the joint is fringed from end to end with a row of closely adjoining fine spinules, with which 2 or 3 short additional rows are associated just internally at about the middle. Labrum crescentic in shape, finely pectinate on margin. Labium distinct, bilobed. Mandibles have thick base and slender apex ending in acuminate cutting edge which accompanies a smaller similar-shaped gnathobasis. First maxillae displaced far anteriorly

close to the base of 1st antennae and just outside the 2nd antennae and represented by sharp falciform claw. Second maxillae just behind mandibles. Basal joint carries 3 short plumose spines at distal end, similar, but far longer, outwardly projecting one a trifle proximally and a very tiny spinule on anterior border. Terminal blade dwindled in irregular shape, pointed at tip and without marginal pectination. First maxillipeds more or less distinctly articulated into 3 joints; basal joint broad, 2nd slenderer and 3rd forked into 2 subequal acuminate blades which are thickly covered with fine spinules on anterior side. Second maxillipeds

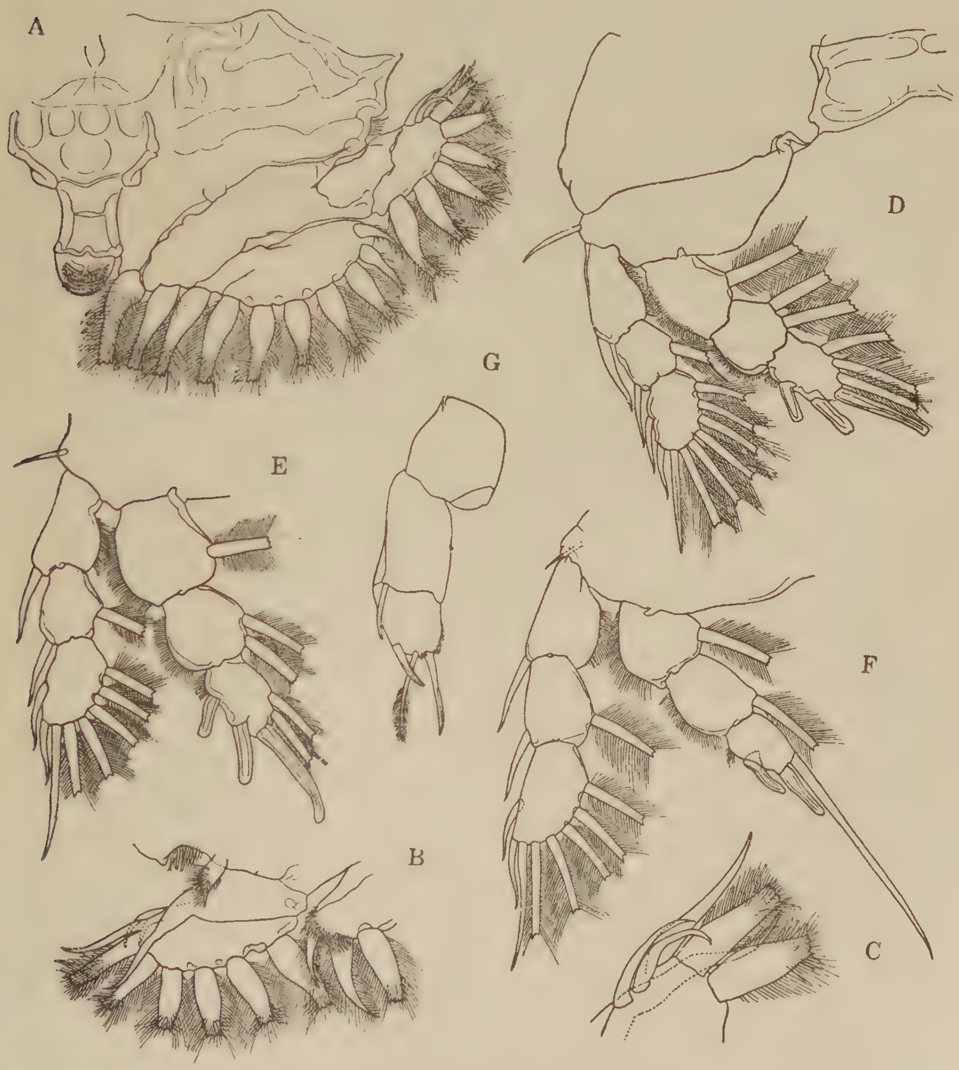

Fig. 6. *Parataeniacanthus rotundiceps* n. sp., female. A, 1st leg; B, exopodite of same, posterior surface; C, outer distal angle of same, anterior surface; D, 2nd leg; E, 3rd leg; F, 4th leg; G, 5th leg. A, D–G ×122, B ×162, C ×305.

in normal position behind 1st maxillipeds, well-developed and consisting of very short crescentic base, much longer, broadly flattened middle joint and equally long slender claw. Middle joint nearly oval in shape, directing forward. Claw folded back, standing close to inner side of middle joint, but curving terminally away from it and ending bluntly. It carries a short anteriorly directing basal process and a series of transverse ridges on inner border.

First 4 pairs of legs biramous, while 5th uniramous. First pair with endopodite composed of 2 flattened, lamellar joints, exopodite much smaller in size, similarly 2-jointed, and protopodite broadly lamellar and 1-jointed. Sterna plate narrow and bearing semicircular accessory lobe closely covered with spinules on surface. Succeeding 3 pairs of legs similar to one another in structure. Both rami 3-jointed, subequal in length and much narrower than endopodite of 1st pair ; protopodite divided by a straight border into larger 1st and smaller 2nd joints and united with the fellow of opposite side by a sternal plate broader than that of 1st legs. Fifth legs 3-jointed, with middle joint somewhat longer tha other 2 which are subequal. Armatures on 5 pairs of legs are listed in the Table III.

Table III. Arrangement of spines and other armatures in 5 pairs of legs in *Parataeniacanthus rotundiceps* n. sp.

Leg	Border	Sternal plate	Protopodite		Exopodite			Endopodite		
			I	II	I	II	III	I	II	III
I	outer	cc	c, 1p		1h	3h			cc, 2p	
	inner		1P′			6P′		1P′	6P′	
II	outer			1h	1h	1h	2h, 1Q	c	c	c, 3H′
	inner				c	1P	6P	1P	2P	3P
III	outer			1h	1h	1h	2h, 1H	c	c	c, 3H′
	inner				c	1P	5P	1P	2P	2P
IV	outer	cc		1h	1h	1h	2h, 1H	c	c	c, 2H′
	inner				c	1P	5P	1P	1P	1H
V	outer				1h	1h				
	inner					c, 1h, 1p				

Plumose spines on 1st pair of legs curled dorsally and surrounded with multiserial hairs almost along entire length, while those on other legs straight and bordered with biserial hairs. Outer spines on exopodite of 2nd to 4th legs sharply pointed, without rim, but same spines on endopodite thicker, of uniform width, ending in blunt tip and with marginal rims. Apical spine on exopodite of 4th legs as long as plumose ones and sharply pointed. Third joint of 5th legs with a central spine plumose and others non-plumose.

Caudal rami slender, as long as last abdominal segment and terminating in 2 unequal, plumose spines and a similar but much shorter internal one. They bear, in addition, 3 very short simple spines ; of these, one is attached to inner margin a short distance in front of terminal spines, another to outer margin at the end and the rest to the same margin at the center.

Male : Allotype. A single male was found seizing the female body with its powerful 2nd maxillipeds. Since a typical male generative system has been observed in this individual, there is not the slightest doubt as regards its sexuality.

Much shorter than female, similar in configuration, having a slender body. Entire length 1.15, carapace 0.40×0.26, 2nd thoracic segment 0.09×0.24, 3rd 0.09×0.22, 4th 0.09×0.17, 5th 0.07×0.15, 6th 0.13×0.14, abdomen 0.28 long, 1st segment 0.10×0.09, 2nd 0.09×0.08, 3rd 0.09×0.08 (all in mm.). Color as in female.

Carapace circular, as long as wide, resembling that of female, but relatively narrower and more or less angular in the rear on either side. First thoracic segment united with head somewhat more completely than in female, though the boundary is demarked by a faint groove. Eyes inconspicuous. Thorax 2/5 as long as body. Second segment 2/3 as wide as carapace, 1/4 as long and trapezoid in shape. Following segments decrease in size successively backward up to 5th segment. Genital segment enlarged, exceeding 2nd segment in length, and yet equaling to 5th in width. It is barrel-shaped, having widely round sides and is distinct from the preceding segment. Abdomen longer than half of thorax and composed of 3 rectangular segments, all similar in length and width.

Second maxillipeds entirely different in structure from those of female. They are more powerful, projecting outward instead of forward and are adapted for seizing female while embracing. Basal joint short, with a stiff spine on inner side. Middle joint long and wide, but somewhat narrowing distally, widely round on outer margin and straight on inner margin except for a deep basal excavation. Along inner margin, the joint is flattened to form a narrow longitudinal area, which is delimited by fine pectination on either side and has 2 short unequal spines at the center. Terminal claw prolonged and curved inward at the tip, fitting in the basal excavation of middle joint when closed. It bears a small quadrate lamina near the base on inner margin, a slight conical bulge a short distance distally and a series of short, closely adjoining, transverse ridges in curved apical part on the same margin. No appreciable sexual dimorphism in the structure of other appendages.

Remarks : There is hardly any doubt in that the new species belong to *Parataeniacanthus*, since it has the 1st thoracic segment indistinctly demarcated from the head. Although YAMAGUTI claims the partial union of the 5th and 6th

thoracic segments in this genus, he depicts a clear boundary between those segments in his figures on *P. pseudorhombi* YAMAGUTI[10] and *platycephali* YAMAGUTI[10]. In the new species, those are quite distinct from each other. The new species may be distinguished from *pseudorhombi* by the posterior borders of thoracic segment being entire and from *platycephali* by the round carapace as well as by the structure of the 2nd maxillipeds.

As YAMAGUTI's species are not accompanied with a male, the foregoing is the first description of this sex from the genus. This may be defined as follows:

Generic diagnosis of the male of *Parataeniacanthus*:

Abdomen 3-segmented. Second maxillipeds prehensile, with terminal claw curved inward being adapted for embracing the female. Otherwise as in female.

References

1) BRIAN, A., 1902. Note su alcuni parassiti dei pesci del Mediterraneo. Boll. Mus. Zool. Anat. Comp. R. Univ. Genova, 1902, No. 115, pp. 1–16, Pl. 1.
2) ———, 1906. Copepodi parassiti dei pesci d'Italia, pp. 1–187, Pls. 1–21, Genova.
3) CLAUS, C., 1864. Beiträge zur Kenntnis der Schmarotzerkrebse. Z. Wiss. Zool., Vol. 14, pp. 365–383, Pls. 33–36.
4) STOCK, J. H., 1953. *Bomolochus solae* CLAUS, 1864 and *B. confusus* n. sp.: two hitherto confounded parasitic copepods, with remarks on some other *Bomolochus* species. Beaufortia, Ser. Misc. Publ. Zool. Mus. Amsterdam, No. 24, pp. 1–13.
5) WILSON, C. B., 1908. North American parasitic copepods: list of those found upon the fishes of the Pacific coast, with descriptions of new genera and species. Proc. U. S. Nat. Mus., Vol. 35, pp. 431–481, Pls. 66–83.
6) ———, 1911. North American parasitic copepods belonging to the family Ergasilidae. Ibid., Vol. 39, pp. 263–400, Pls. 41–60.
7) ———, 1913. Crustacean parasites of West Indian fishes and land crabs, with descriptions of new genera and species. Ibid., Vol. 44, pp. 189–277, Pls. 18–53.
8) ———, 1922. Parasitic copepods from Japan, including five new species. Ark. f. Zool., Vol. 14, No. 10, pp. 1–17, Pls. 1–4.
9) ———, 1932. The copepods of the Woods Hole Region, Massachusetts. U. S. Nat. Mus. Bull. 158, pp. 1–635, Pls. 1–41.
10) YAMAGUTI, S., 1936. Parasitic copepods from fishes of Japan., Pt. 1, Cyclopoida, I, pp. 1–8, Pls. 1–5.
11) ———, 1939. Parasitic copepods from fishes of Japan, Pt. 4, Cyclopoida II. Vol. Jubil. Prof. S. YOSHIDA, Vol. 2, pp. 392–415, Pls. 1–13.
12) ———, 1953. Parasitic copepods from fishes of Japan, Pt. 7, Cyclopoida III, Caligoida IV. Publ. Seto Mar. Biol. Lab., Vol. 3, pp. 221–231, Pls. 1–5.

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A Consideration on Live Transportration of Rainbow Trout *Salmo gairdnerii irideus* G.[1]

(*With 7 Tables and 1 Plate*)

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Introduction

The Fishery Experimental Station of Nagano Prefecture has a small auto-truck which are capable of conveying 150 kg. rainbow trout in 750 liters of water. Although the water in tank is aerated from the oxygen bombs through carbon tubes during transportation to avoid the death of fish for want of oxygen, sometimes hight rate of death occurs during transportation, therefore the causes of those death have been considered to be examined exactly. TANIZAKI, President of the station requested KAWAMOTO and FUJIMURA to study live transportation of trout in the tank from the physiological and biochemical points of view for the purpose of preventing the death of fish.

So, we began to make clear the causes of death of trout by the physiological and biochemical researches. In general, for the live transportation of fish, lowering temperature by putting ice into water and aerating into it from the oxygen bomb have only been carried out in Japan, although such methods are not sufficiently satisfying. But recently, eager demand for an improved method for the live transporting of fish has arisen as the amount of conveying fish is getting greater than formerly.

Methods of Studies and Materials Employed

The wooden tanks containing 30 *l* and 90 *l* of waters respectively were prepared and many kinds of studies have been done by employing waters in the tanks in which were put into 6 kg. and 18 kg. of rainbow trouts respectively instead of employing the water tank in the truck.

Rainbow trout, *Salmo gairdnerii irideus* GIBBONS, of 14.7 to 16.0 cm. body-length and 55 to 60 gr. body-weight, were used as materials which had been reared

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in the farms of the Fishery Experimental Station. The oxygen content in the water in tank of the truck had been studied by INABA and NOMURA (1956), and they reported that in the water, oxygen was added sufficiently under pressure in the equipment. Then, in the first place we began to study as follows : For the study of oxygen consumption of trout, HALL's respiration apparatus (1931) of open system was used, oxygen was measured by the semimicro-method of WINKLER modified by RISCH (1925), and opercular motions were recorded by means of Kymograph. For the chemical analysis of waters in the tank, the nitrogen of protein, amino acid, ammonia and urea were examined by many methods such as Bang's micro Kjeldahl method, Nesslerisation, and Engel's Xanthydrol method, ete.

Results of Experiments

(i) *Normal oxygen consumption of the rainbow trout*

A fish was put into HALL's respiratory chamber containing 500 cc. of water which was set in a glass tank and water was running into and overflowing from the tank during the experiment.

The water in the tank which was entering from the anterior opening of the respiratory chamber was flowing out from the posterior opening of the chamber

Table 1. Showing the data of normal oxygen consumption of the rainbow trout

Body weight g.	Body length cm.	Water temp. °C	O_2-consumption cc/kg/hr
55	14.7	15.5	247
55	15.6	15.0	218
59	15.4	15.7	225
63	15.5	17.5	258
Average	15.3	15.4	237

to the outward, and the amount of the flowing water being regulated from 30 to 100 cc. per minute by a screw cook attached on the rubber tube of the outlet. Leaving the equipment for about 1 hour until the fish in the chamber becomes quiet, the oxygen contents of the water in the glass tank and the outlet water in which fish had respired were determined and the amount of oxygen inspired by the fish was calculated per kilogram per hour as be shown in the Table 1.

(ii) *The influences of polluted waters on the respiration of trout*

To examine the influences of the polluted waters in which trouts were living under the conditions of aeration with oxygen and to prevent rising temperature with adding ice, the following three kinds of experiments were carried out respirations in the normal, polluted and filtered waters were determined by employing the same fish in each of the three experiments.

From the results of Table 2, it may be observed that the polluted water prevents normal respiration of trout and moreover it is seen that the greater the pollution, prevented the more the respiration.

Table 2. Showing the amount of oxygen inspired in different waters (water running 100 cc per min.)

Conditions	Experiment I at 12.7°C, 55g. B.W. fish	Experiment II at 15.5°C, 61g. B.W. fish
O_2-consumption	O_2 cc/kg/hr	O_2 cc/kg/hr
Normal respiration	218	288
In the polluted water	72*	58**
Filtered polluted water	125	117

* The water 21 l in volume containing 6 kg. trouts, turbid with in water and bubbles on the surface after 5 hours.

** The same conditions after 7 hours.

(iii) *Variations of the oxygen consumption and respiratory frequency in different amounts of running water*

By the regulation of a screw cock at the outlet rubber tube, as mentioned above different amounts of water were permitted to flow through the respiratory chamber, and amounts of oxygen consumption and respiratory frequencies were

Table 3. Showing the variations of oxygen consumption and respiratory frequencies of a trout in the different amounts of water flowing, the fish employed was 62 g body weight and 15.5 cm body-length in 17.5°C water temperature.

Amount of streaming water cc/min.	O_2-consumption per kg/hr	Respiratory frequencies per 1 min. (averaged)	Date
30	133	165	August
50	191	154	〃
100	258	153	〃

measured in the same trout as the matter is varied in different individuals. The results are shown in Table 3, the increment of oxygen consumption in a large amount of flowing water shown in this table was believed to be a temporary phenomenon as Meyer has indicated (1935).

The respiratory frequencies of the trout not only varied under the different amounts of water flowing, but also under various conditions and the sizes of the fish as shown in the Table 4.

From the results of the data in Tables 3 and 4, it is observed that the respiratory frequencies are very sensitive to variations in the different conditions and in general, the frequencies for adults are smaller than those of younger trout.

Table 4. Varying respiratory frequencies under the different conditions and the sizes of fish.

Conditions	Body-weight gm.	Respiratory frequencies per min.	Date	Water temp. °C
Normal 4.800 52.53	4,800	52, 53	August	17.0
〃 600 60.62	600	60, 62	〃	17.0
〃	55	99	April	13.0
〃	62	81	〃	10.8
On kymograph	62	110	〃	11.8
In resp. chamb. (per 100 cc wat.)	62	136	〃	11.0
〃 (per 200 cc wat.)	62	130	〃	11.0
In polluted wat.	62	126	〃	11.0

(iv) *Relation between occurrence of the cleaning motion of the operculum and pollution of the waters.*

Although the cleaning motions are not commonly observed in trout under normal conditions, it was found that these motions came to appear as the pollutions increased in the water, and the numbers of the motions increased gradually with increasing pollution (Table 5 and plate XXIII a B.)

Table 5. Showing the relation between the numbers of cleaning motions and conditions of polluted water.

No. of exp.	Respiratory frequency per min.	Numbers of cleaning motion per min.	Time sec.	Wat. temp. °C
1st	132	5, 6, 5	26-22	11.5
2nd	152	2.5, 2.1	60-70	12.0

In the first experiment shows the experimental results of the water of 24 *l* in which 6 kg. of trout was contained and aeration was effected through a carbon tube for 1 hr 30 min. at 11.5°C. In the second experiment, water of 90 *l* in which 18 kg. of trout was contained and aeration was effected through small pores in the brass tube for 5 hr 30 min at 12.0°C water temperature.

From the results of the experiments it will be supposed that the increment in the numbers of cleaning motions indicates increasing respiratory, difficulty due to the disturbance of the normal breathing of the fish.

(v) *Chemical analysis of the polluted water*

During aeration of the water in the tank, the water was bubbled, turbid with organic suspensions.

Then, one of our writers, FUJIMURA, studied qualitative analysis of the water to determine what kind of chemical substances may appear in the water in the wooden tank (Table 6).

Table 6. Qualitative analysis of the polluted waters.

Experiments	Control water	Test water
pH	6.4	6.8–7.0
Color reaction of amino acids and proteins		
Ninhydrin reaction	–	+
Millon's 〃	–	–
Heller's 〃	–	–
PbS 〃	–	–
Sakaguchi's 〃	+ ?	+ ?
Molisch 〃	–	–
Biuret 〃	–	–
Precipitation reactions of proteins		
Trichlor acetic acid	–	–
Sulphosalicylic acid	–	–
Meta phosphoric acid	–	–
Almin	–	–
Boiling test	–	–
Picric acid	–	–
Reducing reaction		
Fehling's test	–	–
Trommer	–	–
Benedict	–	–
Nessler's reagent	–	+
Xanthydrol (*Urea*)	–	(trace)
NaClO (*Urea*)	–	(trace)
Jodoform reaction	–	± ?

Table 7. Total and ammonia nitrogens in the waters polluted by 18 kg. of trout which were kept in water 90 *l* aerated with oxygen at 15°C

No.	Conditions	Total nitrogen mg/dl		Ammonia N mg/dl		Amino N[1] mg/dl	Urea N[2] mg/dl
		Amount determined	Amount increased	Amount determined	Amount increased		
1	Before introducing fish	0.342	0	0.088	0	0.09	0 ?
2	After introducing fish.	—	—	0.388	0.300	—	—
3	2 hrs.	0.762	0.42	0.544	0.456	—	—
4	4 hrs. 6 〃	—	—	0.85	0.762	—	—
5	8 〃	1.380	1.038	1.13	1.0	0.09	—
6	10 〃	1.935	1.593	1.32	1.32	—	—
7	12 〃	2.050	1.708	1.66	1.572	—	—
8	13 〃	2.32	1.978	1.64	1.552	—	—
9	13 h.10 min.	2.32	1.978	1.66	1.572	0.136	0.14

1) Van Slyke's method. 2) Engel's Xanthydrol method.

From the data in Table 6, it was observed that ammonia nitrogen existed in addition to small amounts of amino acid and urea in the water, then further quantitative analysis of total and ammonia nitrogens were carried out by Kjeldahl and Nessler's reagent methods as shown in Table 7.

The data in Table 7 show the quick increment of total and ammonia nitrogen which may be supposed to have some injurious effect upon the trout.

Discussion

In the water running at 100 cc per 1 minute, it was found that the rainbow trout of 55 to 63 gms. in body-weight consume oxygen from 218 to 258 cc per kg. per hour in the water temperature from 15° to 17.5°C as be seen in Table 1. These data approximate those of brown trout according to GARDNER and LEETHAM (1914) and are supposed to be recognized as normal respiration values after 24 hours starvation. However, to mention oxygen consumptions of fish, we have to consider the water volumes streaming over the fish, because the amounts of oxygen consumed are growing much in accordance with the increment of the volumes streaming as is shown in Table 3. This fact was coincided with the result of MEYER's experiment (1935) of the oxygen consumption of *Uranoscopus scaber*. Then it must be remembered that the amount of streaming water ought to be taken into consideration when oxygen consumption of fish is discussed, although such increment might be a phenomenon in a short time.

As shown in Table 2, oxygen consumption suddenly decreased when the fresh water was replaced polluted, turbid, bubbled and suspension existing water, but the decrement of oxygen consumption became recover to some extent by filtering the polluted water.

These results show us that the polluted water prevents normal oxygen consumption, and is influencing on the difficulty of normal respiration of the fish.

The respiratory frequencies are very variable as shown in Tables 3 and 4; for instance, they differ according to the growth stages and under environmental conditions, but the fish always breath in regular amplitudes except in the polluted water. When the water was polluted, abnormal rhythm, called cleaning motion occurred. Under these experiments, the cleaning motion was observed once every 5 to 6 minutes in the water that has been polluted for 1 hr. 30 min., while that was increased once every 2.5 to 2.1 minutes in water polluted for 5 hr. 30 min.; and the more the pollution increased, the more the cleaning motions became (plate XXIII A and B).

Normal respiration may be disturbed very much by such many motions, as trouts must expire the water from the mouth frequently during their respiration. The amount of oxygen consumed, recovered to some extent as seen in the 3rd

line of Table 2 when to water was filtered and this fact shows that some part of preventing normal respiration exists in the suspension substance such as faeces, mucous membranes, etc. in the polluted waters.

Recently BLACK (1956) reported that as a result of vigorous activity during transportation, the stores of glycogen in muscle are converted to energy available for the performance of work by the contracting muscles, and to various metabolites, the chief of which is lactic acid in the blood.

Then, as fish receive hard motion during transportation increment of lactic acid in the blood, will occur and *pH* in it will be decreased and the value of t_l (KROGH and LEITCH, 1919) in the oxygen dissociation curve will properly increase. Therefore, it will be considered that respiration of fish will become very hard by increment of lactic acid in the blood in addition to the various facts mentioned above.

From the data in Table 6, we found that in the polluted water which trout had been living for many hours, ammonia nitrogen with small amounts of amino acid and urea existed, and quantitative analysis of the water, Table 7 showed that the total and ammonia nitrogens increased rapidly with the elapse of time.

GERKING (1955) experimented that the bluegills excrete about 7 mg of nitrogen/1 kg cal, which is three and a half times greater than in homoiothermous animals. This confirms other work on the nitrogen balance of frogs. Then he said that there may be a fundamental difference in the protein metabolism of homoiothermous and poikilothermous animals. The authors considered that these nitrogens which came from the excretory of fish might be influencing on the live trouts very much, because BROCKWAY indicated that the existence of ammonia was harmful for trout (1950) and KAWAMOTO (1957), reported that the production from fish farms were much disturbed by the existence of excretory substances, especially, ammonia nitrogen. From the pharmacological point of view, it is generally recognized that ammonia nitrogen has an anaesthetic effect on the nerves of animals, and therefore it may be supposed that such ammonia must be acted upon the fish.

Conclusion

From the results of experiments mentioned above, it may be concluded that since water which contains a large number of rainbow trouts will become turbid and polluted very much in a short time then if the fish have to remain in the poulluted waters they are subjected to a serious danger and hight mortality may resulted. Therefore, we arrived at the conclusion that the live transportation of fish can be efficiently transported when the polluted waters are purified.

The suspended materials in the polluted water were removed easily by pass-

ing the water through a layer of sand, and ammonia which come from excretory substances was removed by employing ion exchange resin, IR, 120, Amberlite.

Thus, we consider that the transporting live trout will become more safely, by purifying the polluted waters with these two methods mentioned above in addition to lowering the water temperature and adding oxygen. The depth of sand layer, and amount and kind of ion exchanged resin will be reportedsub sequently.

At this occasion, we must express thanks to members of our laboratories assisted us in these works during the course of the study.

Literature

BLACK, E. C., 1956: Appearance of lactic acid in the blood of kamloops and lake trout following live transportation. The Canadian Fish Culturist, No. 18, pp. 20–27.

BROCKWAY, D. R., 1950: Metabolic Products and their effects. Prog. Fish-Cult., 12, pp. 127–129

GARDNER, J. A. and C. LEETHAM, 1913: On the respiratory exchange in fresh water fish. Part 1 (on brown trout). Bio-chemi. Jour., 8.

GERKING, S. D., 1955: Endogenous nitrogen excretion of bluegill sunfish. Physi. Zool., 28, 4, pp. 283–289.

HALL, F. G., 1931: The respiration of puffer fish. Biol Bull. 61:457–467.

INABA, D. and M. NOMURA, 1956: Some experiments on the transportation of live fish in aerated water. Aquiculture, 4, 1, pp. 34–42.

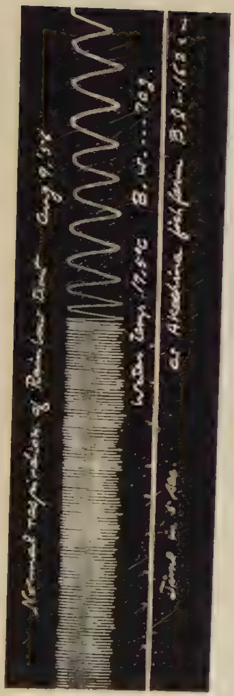
KAWAMOTO, N. Y., 1957: Studies during intensive carp culture in Japan Prog. Fish-Cult. 19.1:26–30.

KROGH, A. and L. LEITCH, 1919: The respiratory function of the blood in fishes. Jour. Physi., 52, 288–300.

MEYER, H., 1935: Die Atmung von *Uranoscopus scaber* und ihre Abhängigkeit vom Sauerstoffdruck. Z. vergl. Physiol. 22 (indirectly cited).

PLATE XXIII

A



B

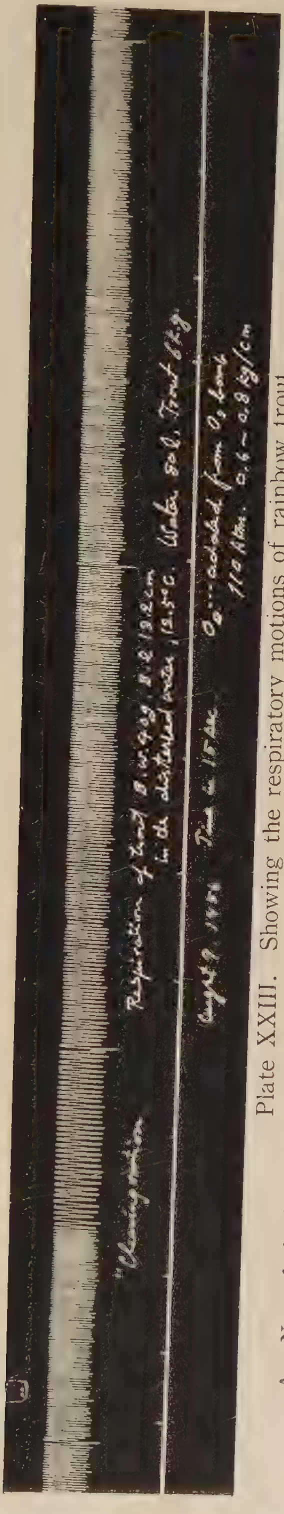


Plate XXIII. Showing the respiratory motions of rainbow trout

A. Normal rhythm, no cleaning motions were observed.

B. Showing the appearance of cleaning motions in the respiratory rhythms when the polluted water was given to the trout.

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Prefectural University of Mie,
Vol. 2, No. 3, July 30, 1957.

Studies on Effects by the Pond-Areas and the Densities of Fish in the Water Upon the Growth Rate of Carp (*Cyprinus carpio* L.)[1]

(*With 5 Text-figures and 14 Tables*)

N.Y. KAWAMOTO[2], Y. INOUYE[3], and S. NAKANISHI[4]

There are many studies on the effects by pond-areas and the densities of fish in the water upon the growth rate of fishes, such as KAWAJIRI (1928); KAWAJIRI, HATA and MURAI (1930); KOYAMA (1956) and YOSHIWARA (1952), etc. All of them have reached the same conclusion that the more the density of population of fish in pond increased the more the growth rates of them decreased. In this research, the writers are not intending to pursue the same experiment, but to clarify the reason why the results of growth rate differ in varying areas and densities in the pond. Because the study on the causes of those different results has not yet been taken place, and moreover such research is supposed to be very important to fish culturist. In the present paper, however, the results of experiments will be described and the conclusion of the research will be explained in the next paper.

Methods and Materials

Present experiments were carried out at the Fresh-water Fishery Experimental Station of Mie Prefecture from June to December, 1956. Each two ponds in every three kinds of areas (A, B and C) of concrete construction were selected for this purpose. The depth of water of all these six ponds was regulated to 30 cm during the experiment. Young carps of almost the same size, which hatched in the Spring, were put into those ponds. The names, areas of ponds, numbers of carps put into there and those of fish in the ponds against 1m² in area, will be shown in the following Table 1.

As seen in the table, the rates of densities in each two ponds in every three kinds A, B and C were 1:2, and the deviations of numbers of fish in ponds against 1m² in area are almost equal within the limit of 10 per cent.

1) Aided by the Governmental Fund for Science Research.
2) Professor of Faculty of Fisheries, Pref. Univ. of Mie.
3) Director of Fresh water Fishery Exp. Station of Mie.
4) Member of the Fishery Exp. Station.

Table 1. Showing pond-areas, the numbers of fish in the ponds and rate of reared in $1m^2$.

Pond Division	Pond No.	Area m²	Area Tsubo	No. reared carp	Density of carp in pond	Rate reared
A	I	2.36	0.72	24	10.4	1
	II	2.36	0.72	48	20.4	2
B	I	3.22	0.98	30	9.4	1
	II	3.22	0.98	60	18.1	2
C	I	13.41	4.06	120	9 0	1
	II	13.41	4.06	240	18.1	2

The water was poured into these ponds from the well near the ponds, but it contained salts somewhat (Cl' contained 0.515–0.568mg/L), because the station was near the coast of Bay of Ise.

Constituents of fish food given from June 20th to July 1st was as follows;

rice bran 70%
wheat flour .. 30%
} were given, prepared by water

From July 2 to the end of October, the following food of amount of one tenth of the weight of carps have been delivered, and 0.5 tenth of the food was

Table 2. Showing average data in every month of lengths, heights and weights of carps in the experimental ponds.

	Pond No. \ Date	VI, 13	VII, 20	VIII, 20	IX, 20	X, 20	XI, 20	XII, 20
Body length (cm)	A I	2.89	3.92	4.94	6.19	6.86	7.02	6.99
	A II	2.82	3.77	4.33	5.45	5.72	6.32	6.21
	B I	2.91	4.28	5.38	6.10	7.12	7.14	7.15
	B II	2.84	3.77	4.67	5.45	6.04	6.28	6.55
	C I	2.92	4.43	5.28	6.25	6.79	7.37	7.25
	C II	2.75	3.85	4.64	5.38	5.77	6.01	6.13
Body height (cm)	A I	0.79	1.10	1.51	1.82	2.28	2.34	2.20
	A II	0.72	1.11	1.42	1.95	1.91	2.07	2.01
	B I	0.77	1.30	1.71	1.81	2.22	2.34	2.30
	B II	0.76	1.08	1.46	1.60	1.99	2.06	2.09
	C I	0.85	1.30	1.69	1.81	2.23	2.46	2.36
	C II	0.72	1.16	1.45	1.57	1.86	2.01	1.96
Body weight (g)	A I	0.63	1.58	3.54	6.31	8.50	10.77	10.12
	A II	0.66	1.50	2.79	4.43	5.71	7.92	6.90
	B I	0.65	2.01	4.50	6.21	8.90	10.19	10.34
	B II	0.66	1.92	2.85	4.29	6.40	7.02	7.01
	C I	0.64	2.22	4.31	6.47	9.10	11.30	10.10
	C II	0.66	1.50	2.55	4.51	5.75	6.72	6.10

used in November as the temperature of water had decreased, while from November 29 to the end of December the food was stopped as the temperature had been lowering below 10°C.

rice brand	50%	were given, after prepared by water
shrimp meal..................	20%	
meal of pupa of silk worms	10%	
wheat flour..................	20%	

Thus, on the 20th of every month, the body weight, length and height of all carps in each pond were measured after draining off all the waters, and also determined *pH*, transparency, and ammonium nitrogen in the water with Nessler's reagent. Temperatures of waters and air were measured at 10 o'clock in every morning. Sometimes, studied on the total nitrogen in waters, containing organic substance and in the filtrates with micro Kjeldahl method, and also oxygen content was measured by Winkler method. The fish lost during rearing were supplemented with those of almost the same size from reserve pond.

Results of Experiments

The results of growth of carps during experiment were obtained as will be shown in Table 2. Arithmetical averages of each data determined in every month are shown in the table: From the results the writers found that every three data of I- and II-ponds in A, B and C kinds coincided well with each other. Then these data were averaged in Table 3 and shown in Figures 1 and

Table 3. Showing data of growth rates averaged, the results of ponds I and II.

	Date / Pond No.	VI, 13	VII, 20	VIII, 20	IX, 20	X, 20	XI, 20	XII, 20
Body length (cm)	I	2.91	4.21	5.20	6.18	6.93	8.18	7.13
	II	2.80	3.79	4.55	5.43	5.84	6.20	6.29
Body height (cm)	I	0.80	1.23	1.64	1.81	2.24	2.38	2.29
	II	0.73	1.12	1.44	1.71	1.82	2.05	2.02
Body weight (cm)	I	0.64	1.94	4.21	6.33	8.83	10.75	10.19
	II	0.66	1.63	2.73	4.41	5.95	7.22	6.67

Table 4. Amount of Cl' in pond waters.

Date	Amount of Cl'
VI, 18	0.529 g./L
VII, 20	0.532 〃
VIII, 20	0.530 〃

2. These figures showed clearly that the data were influenced by the densities of ponds of 1:2, and almost any other marked differences were observed in varying areas of the ponds with in the limit of this experiment.

Table 5. Oxygen contents in each ponds.

Date	Wat. temp. and O_2	A–I	A–II	B–I	B–II	C–I	C–II
IX, 27, a.m. $6^h 50^{min}$	Wat. temp. °C	17.2	17.2	17.3	17.4	17.4	17.2
	O_2 cc/l	6.18	6.21	6.15	6.27	6.25	6.16
X, 24, a.m. $5^h 30^{min}$	Wat. temp. °C	17.7	17.6	17.8	17.7	17.6	17.7
	O_2 cc/l	4.51	4.13	4.56	4.63	4.49	3.56

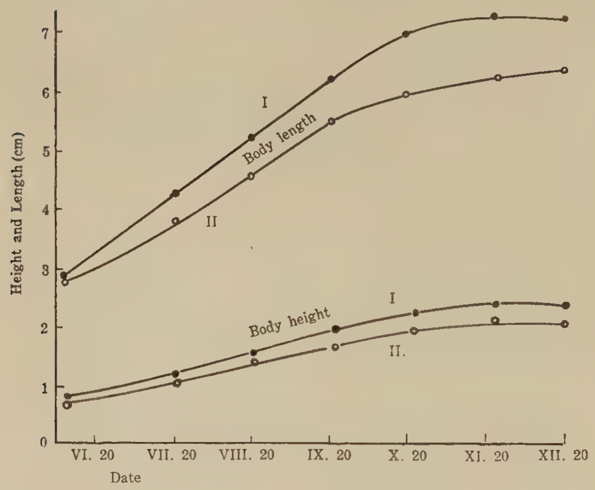

Fig. 1. Showing the increments of body length and height of carps in ponds I and II.

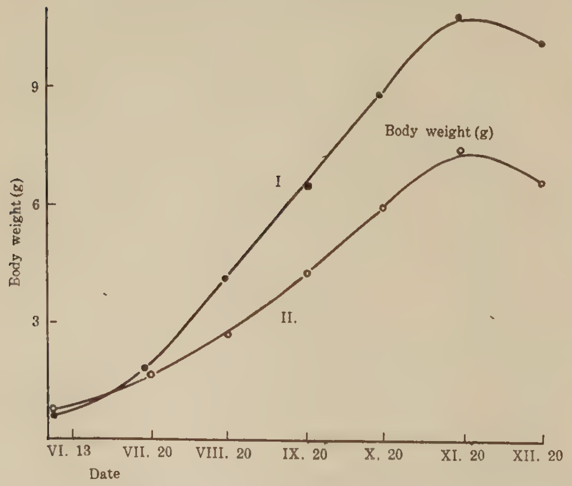

Fig. 2. Showing the increment of body weight of carps in ponds I and II

The waters in the ponds containing salts as mentioned above and the amount of Cl' is shown in Table 4.

The oxygen content in each pond is shown in Table 5.

The data in the table show us that the amount of oxygen content in each pond is changing with the equal rate.

While values of *pH* in the waters were shown almost the same as will be seen in Table 6.

Average data of temperatures of waters and air in the course of this experiment are shown in Tables 7, 8 and Figures 3 and 4.

As waters in these ponds used were poured from the well, they were totally transparent in the beginning and the bottom was seen form the water surface in the end of the

month, though some green planktons (phytoplankton) appeared. The planktons gradually increased from July to August and the transparencies of the pond waters decreased as is shown in Table 9.

Table 6. *pH* value measured P.R. (IX, 20 '56).

A–I	A–II	B–I	B–II	C–I	C–II
8.1	8.0	8.1	8.15	8.1	8.15

(Salt errors are not reduced)

Table 7. Showing average data of air temperatures.

VI	VII	VIII	IX	X	XI	XII
22.6°	26.1°	26.8°	24.1°	19.4°	13.1°	9.4°

In 29th of October, species and numbers of these phytoplanktons in each ponds were measured and identified by the courtesy of Dr. T. Itoh and Mr. Koyama, and were given in Table 10.

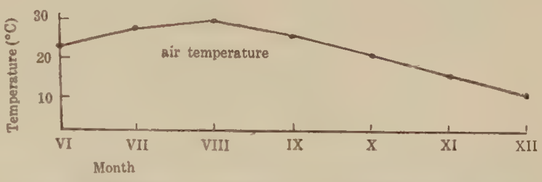

Fig. 3. Showing changes of air temperatures during experiment.

This table shows that the numbers of planktons in the two ponds of A were markedly greater than any other four ponds of B and C. Moreover, in both ponds of A and C except B, numbers of planktons in ponds II were greater than those of pond I.

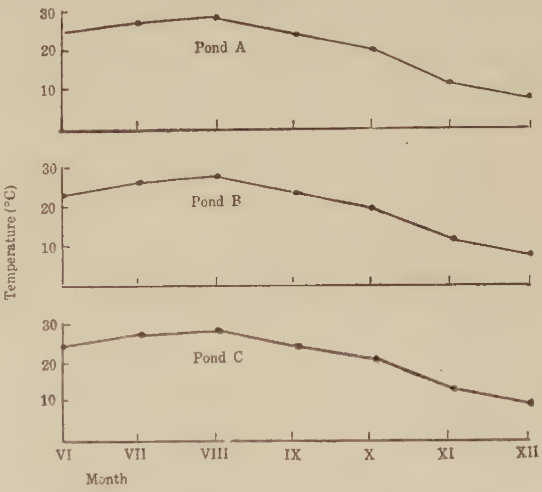

Fig. 4. Showing changes of water temperatures in the ponds A, B and C.

Next, expecting for existence of ammonium nitrogen in the waters, the writers measured it by means of Nesslerization on Sept. 20, but at that time almost any nitrogen was not found in each pond as was shown in Table 11, upper column, while, when they measured it again on Nov. 13, considerable amount of it was observed in each pond as will be seen in lower column in the table.

However as numbers of these data are rather small, further measurement must be required for discussing the problem of the amount of nitrogen.

Table 8. Showing averaged data of water temperatures.

Pond No. \ Month		VI	VII	VIII	IX	X	XI	XII
A	I	24.0	27.1	28.1	25.0	20.7	12.7	9.2
	II	23.9	27.0	28.0	25.2	20.1	12.7	9.3
B	I	33.9	26.9	28.1	24.8	20.4	12.6	9.4
	II	33.9	29.1	28.2	24.9	20.2	12.7	9.3
C	I	37.6	27.0	28.0	24.8	20.1	12.8	9.4
	II	33.9	26.9	28.1	24.7	20.0	12.9	9.4

Table 9. Showing transparencies of pond waters measured by porcelain plate of 5cm in diameter. Oct. 29, '56

Pond No.	A–I	A–II	B–I	B–II	C–I	C–II
Transparency	2.6	2.2	2.9	2.3	2.8	3.2

Table 10. Showing species and numbers of phytoplankton in each pond.

Species \ Pond No.	A–I	A–II	B–I	B–II	C–I	C–II
Cyanophyceae						
Cylindrosphaerium sp.	4.13	7.74	0.31	0.14	rr	0.38
Microcystis flos-aquae			r	cc	r	c
Dactylococcopsis irregularis	rr	rr	rr	rr	rr	rr
Chlorophyceae						
Oocystis solitaria	0.15	0.07	c	0.02	rr	rr
Oocystis Borgei	r	r	r	r	0.01	0.02
Golenkinia radiata	c		c	0.10	0.11	0.06
Tetraëdron muticum			c	r		
Ankistrodesmus falcatus			rr			
Kirchinerilla sp.	r	r	r	rr	rr	r
Scenedesmus abundans				rr		
Desmidiaceae						
Cosmarium sp.	r			r	rr	
Diatomaceae						
Nitzschia filiformis	rr	rr	rr	r		
Nitzschia spectabilis					rr	rr
Cyclotella sp.					rr	
Fragellaria sp.					c	
Total ind. 1cc	4.28	7.81	0.31	0.26	0.12	0.46

Total nitrogens in waters containing plankton, and in filtrates of the ponds, were measured with micro-Kjeldahl method and the results are shown in Table 12 as following.

Table 11. Showing amounts of ammonium nitrogen contained in each ponds. (at noon).

	Pond No.	A–I	A–II	B–I	B–II	C–I	C–II
IX. 20*	Transparency (cm)	2.6	2.2	2.9	2.3	2.8	3.2
	NH_3-N mg/100cc	trace	0	0	trace	0	0
XI, 13**	Transparency (cm)						
	NH_3-N mg/100cc	0.375	0.429	1.000	0.300	0.333	0.375

* Average temperature 25.5°C. ** Average temperature 14°C.

Table 12. Showing total nitrogens in waters with organic substance, in filtrates and in solid matters in the waters.

		Total nitrogen mg/100cc		
		Water in 100cc	Filtrate in 100cc	Solid matters in 100cc water
A	I	2.380	0.207	2.173
	II	1.680	0.218	1.462
B	I	1.960	0.196	1.764
	II	1.680	0.213	1.467
C	I	2.250	0.151	2.099
	II	1.680	0.207	1.473

Data in this table show that the amounts of total nitrogen in the water with plankton were always larger in ponds I of A, B and C respectively than those in ponds II, and on the contrary, in the filtrates, those was smaller in ponds I than in ponds II. Therefore, amounts of nitrogen in the solid matters in those ponds were larger in ponds I than in ponds II.

Consideration

In summarizing the results of these experiments, the Figures 1 and 2 show that the rates of growth of carps differed in accordance with the different densities of fish in the water and almost any other changes were not observed in the different areas of ponds within the limit of this experiment. The growth rates of length height and weight of the body, were markedly larger in ponds I than in pond II.

Then, the writers considered the reasons why such changes of growth came from in ponds I and II, although such phenomena were observed in many others.

To ascertain whether the growths of the carps in ponds I and II will be applied to the logistic curve or not, which is generally recognized as the growth curve of animals, the writers calculated the equation (1) with data of body weight in Table 2, column 3.

The equation of logistic curve is as follows:

$$y=\frac{L}{1+e^{a-bx}} \qquad (b>0) \qquad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

While y represents weights of growth in every month, L is maximum value of the weight ($\equiv y_\infty$), a and b are constants, x is time and every of them are positive numbers.

When equation (1) is applied logarism.

$$\log\left(\frac{L}{y}-1\right)=(a-bx)\log e \quad \cdots\cdots (2)$$

When the writers put

$$a\log e=A \quad \cdots\cdots (3)$$

$$b\log e=B \quad \cdots\cdots (4)$$

Then the equation (2) is as follows;

$$\log\left(\frac{L}{y}-1\right)=A+Bx \quad \cdots\cdots (5)$$

y expresses data of column 3 in Table 3 and L is applied to the datum of weight in November in the table, and when the writers calculated equation (2) by these data, numbers of Y and X in Table 13 were obtained. Thus the numbers

Table 13.

Month	$\log\left(\frac{L}{y}-1\right)=Y$	x(No. of days)$=X$	X^2	XY
VI	1.19866	0	0	0
VII	0.65167	30	900	19.55010
VIII	0.20656	60	3,600	12.39360
IX	−0.15614	90	8,100	−14.05266
X	−0.66354	120	14,400	−79.62480
Average	$X\overline{Y}=0.247438$	$X=60$		

of $\log\left(\frac{L}{y}-1\right)$ and X in this Table are plotted on the two axises; and the data of ponds I and II from June to October are expressed in the two straight lines as will be shown in Figure 5. Therefore the writers will be able to confirm that the both growth rates of the carps coincided with logistic curves.

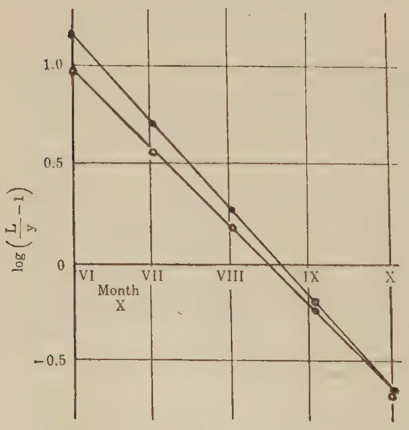

Fig. 5.

When the writers calculated coefficients A and B by least square.

$$B=\frac{\Sigma(Yi-\overline{Y})(Xi-\overline{X})}{\Sigma(Xi-\overline{X})^2}=\frac{\Sigma\, YiXi-N\overline{X}\overline{Y}}{\Sigma\, Xi^2-N\overline{X}^2}$$

$$=\frac{-135.96510}{9,000}=-0.01511 \quad \cdots\cdots (6)$$

$$A=\overline{Y}-B\overline{X}=0.247438$$

$$-(-0.01511)\times 60=1.15404 \quad .. (7)$$

Then the values of a, and b are

obtained from (3) and (4), by applying the data of (6) and (7).

$$a=2.65724$$

$$b=\frac{-(-0.01511)}{0.4343}=0.03479$$

The growth curve of carps in ponds I expresses as follows;

$$y=\frac{L}{1+e^{2\cdot65724-0\cdot03479x}}$$

From the data of ponds II in Table 3, Table 14 is given.

Table 14.

Month	$log\left(\frac{L}{y}-1\right)=Y$	x(No. of days)$=X$	X^2	XY
VI	0.9974	0	0	0
VII	0.5318	30	900	15.954
VIII	0.2163	60	3.600	12.978
IX	−0.1958	90	8.100	−17.6220
X	−0.6706	120	14.400	−80.4720
Average	$\bar{Y}=0.17582$	$\bar{X}=60$		

$$B=\frac{-121.908}{9,000}=-0.013545$$

$$A=\bar{Y}-B\bar{X}=0.96852$$

Then

$$a=2.22776$$

$$b=0.03119$$

The growth curve of carps in ponds II in weight expresses as follows;

$$y=\frac{L}{1^6+e^{2\cdot2277-0\cdot03119x}}$$

It was observed clearly that the growth curves of carps in weight are changed in accordance with the densities of the fish in the waters in spite of different areas of the ponds and the rates of growth were found to be natural by the application of logistic curves.

Then, within the limit of these experiments, the writers considered that the reason why the rates of growth of carps which have been reared in the same methods were larger in the ponds of small density than in the large, regardless of almost the equal conditions of factors, such as the depth of the water (30cm), quality and quantity of foods, water quality (amounts of Cl' in table 4 and *pH* in Table 6), oxygen content (Table 5), and temperatures in the air and waters (tables 7 and 8).

The transparencies of the waters in these six ponds varied and had no connection with the different numbers of green algae existed as are shown in

Tables 9 and 10. The numbers of plankton in ponds A–I and II, were markedly greater than with those in ponds B and C. In ponds I of A and C except B, the numbers of them were greater than those in ponds II of the two as mentioned above.

Anticipating great amount of ammonium nitrogen in the waters by the excretory substances of carps and the decomposition products of remained foods, the writers measured it and obtained the results in Table 11. The fact that the nitrogen was not observed in the measurement of September in spite of large amount contained in November, is very questionable but it may be interesting points and are required further studies.

The total nitrogens in the filtrates and in the solid matters of the three kinds of pond waters are shown in Table 12. In the table, the nitrogens in the filtrates were alway smaller in ponds I than those in ponds II, while, on the contrary, those in solid matters were larger in ponds I than in ponds II.

In Tables from 7 to 12 in which different data were shown in each pond, the variations of data in Tables 7 and 8 were almost equally, while in Tables 9 and 10 were changing irregular. However, as those in Tables 11 and 12 varied regularly, it was considered that the regular variations might be related to the densities in the ponds in comparing with the curves in Figures 1 and 2.

Moreover, it is clearly known that the amounts of nitrogens in the filtrates are smaller in the ponds I in which the carps reared in smaller densities, and also the growth rates are larger.

BROCKWAY (1950) and KAWAMOTO reported that the growth rates of fish depended on the amount of ammonium nitrogen which was excreted from the fish, and this fact may be supposed to some connection with the fact mentioned above.

It is considered that the different amount of ammonium nitrogen in the ponds in September and November as shown in Table 11, may be caused by absorption of ammonia by phytoplanktons at the time of carbon-assimilation, because about 10°C in temperature varied in those two months. These facts will be explaned clearly in further researches.

Conclusion

In conclusion, one cause of the changing rates of growth of carps which were reared in the different densities, was considered, to be depended upon the amount of ammonia and total nitrogens that the fish excreted, and different areas of ponds were not related to the growth in the limit of this experiment. Decrements of growth of carps in December (as shown in table 2) were supposed to be caused by the lowering of water temperature and suspending their food.

Summary

1. In each two ponds in the three kinds of different areas, different numbers of carps (the rates 1:2) per 1m² were reared in the same way by feeding on the same food for 7 months and their growth rates were measured.

2. The growth rates of the fish were able to apply to the equation of logistic curve of animal growth.

3. In the results of these experiment, the growth rates were paralleled to the densities in the water and indifferent in the various areas of ponds within the limit of this experiment.

4. Summarizing the data of physical and chemical factors, it is supposed that ammonia and total nitrogens may be related to the growth of carps.

Acknowledgment

The writers express their hearty thanks to Director M. MIYAMURA and other members of Ise Branch of Mie Fishery Experimental Station who assist us during our study, and also thankful for Dr. T. ITO, KOYAMA and J. KONISHI of our Faculty who aided us on the research.

Literatures

BROCKWAY, D. R., 1950: Metabolic products and their effects. Prog. Fish-Cult., 12, 127–129.

KAWAJIRI, M., 1928: Studies on the density of fish in the water I. Report Imp. Fish. Inst., 24, 1, 11–15.

, 1930: On the experimental results of the pond-culture of rainbow trout, brook trout and common trout. Report Fish. Exp. Stat., 1, 1, 84–142.

KAWAMOTO, N. Y. 1957: Studies during intensive carp culture in Japan. Progr. Fish-Cult. 19, 1, 26–30.

KOYAMA, H., 1956: Population and weight increase in pond carp culture of baitted and non-baitted, with consideration on the productivity of stream water. Report of Fresh Water Fishery Exp. Labo., no. 25.

YOSHIWARA, T., 1952: Effects of area of a pond and the density of population on the growth of carp, (*Cyprinus carpio* L.). Research on Population Ecology, I, pp. 122–135.

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Geographical Distribution of Bottom Fishes in Japan

(With 2 Table)

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The present report includes the comparison of the geographical distribution of the bottom-fish obtained at four famous fisheries extending from north to south in adjacent seas of Japan.

One of the representative northern fisheries is located at a station off Kushiro, Hokkaido ; the second representative fishery is at the Kumanonada station off Mie Prefecture, and the third is located in Suruga Bay, situated off the central island of Honshu. The fourth, and southern, fishery is at a spot off Kochi Prefecture of Shikoku.

Here we have considered the comparative distribution of the bottom-fish obtained at the above mentioned bottom-fisheries.

The oceanic properties of the four fisheries are somewhat different we have considered many different data ; water temperature and the salinity of each layer and depth, as well as the nature of the bottom.

The temperature date for each layer collected from the surface to the bottom (the deepest 3000 fms.), showed a variation of 22°C to 10°C in all of the fisheries. The highest and lowest bottom temperatures for the four different fisheries, as recorded from our observations, were from 22° to 10°C.

The vertical distribution of water temperatures depends on many factors, such as : seasonal, diurnal, and sudden local changes in air temperature which are sometimes accompanied by vertical circulation.

Table 1. Water temperatures of each depth at the four stations

Station \ Depth	0 m	50 m	100 m	200 m	300 m
Suruga Bay, Honshu	19.82—20.73,	19.23—20.39,	16.49—17.34,	12.18—12.49,	9.82—10.00
Kumano Nada, Honshu	15. 0—15. 6,	14.48—15.53,	14. 3—15. 3,	12.45—15.14,	10.54—13.54
Off Tosa, Shikoku	21. 5—22. 0,	20. 0—21. 0,	17. 5—18. 5,	14. 0—14. 5,	10. 0—11. 5

To avoid the variations of seawater temperatures occurring in each of the fisheries, we have compared the oceanic properties found at a similar season in

the four fisheries. From this standpoint, we have chiefly considered the data observed in winter.

From the data mentioned in table 1, it will be noted that the range was considerably less for the bottom waters than for the surface waters.

Table 2. Salinities of each depth at the four stations

Station \ Depth	0 m	50 m	100 m	200 m	300 m
Suruga Bay, Honshu	18.83—18.97,	18.80—18.95,	19.06—19.10,	19.04—19.06,	19.01
Kumano Nada, Honshu	19.12—19.25,	19.09—19.22,	19.07—19.20,	19.03—19.18,	18.98—19.11
Off Tosa, Shikoku	17.77—18.81,	18.95—19.37,	19.09—19.27,	19.05—19.10,	18.82—19.01

Regarding the salinity, the changing range was not so prominent as the water temperature range in each depth layer. Changes of salinity in the four stations varied from 17.77 to 19.37‰ C. Perhaps the salinity is not affected by the depth of the sea and may not govern the distribution and abundance of bottom-fish.

The factors governing the distribution and abundance of bottom-fish have been for many years, and still are, subjects of investigation. Currents, temperatures, salinity, the chemical composition of seawater and bottom natures have been recognized as important factors which have to be taken into consideration.

Comparing the number of species, genera and families from the four fisheries, the following table may be considered.

Fisheries grounds	Off Tosa Shikoku	Kumano Nada	Suruga Bay	Off Kushiro Hokkaido
Species	451	199	225	134
Genera	299	51	85	93
Families	124	71	78	45

From the above table, we have assumed that the bottom-fish fauna in the northern region of Japan has a less number of species than in the southern region as shown in the pelagic littoral fish fauna. Although the present surveys are not completely finished, and the comparison of the number of species and genera can not be considered absolutely, to some extent we may draw the above conclusions.

As far as the number of species from northern and southern regions are concerned, 451 species are found from the fisheries off Tosa, Shikoku, in the southern region of Japan, and 134 species from off Kushiro in the northern region. Thus the ratio of species may be 1:3.3, being less in number in the North than in the South.

The peculiarities for the geographical distribution of bottom-fish exhibit the endemic or restricted species, genera and families. Here we consider the peculiar families in the southern and northern fisheries

a). The families restricted from the southern fisheries off Tosa, Shikoku.

Orectolobidae,	Carchariidae,	Isuridae,
Echinorhinidae,	Dalatiidae,	Lepidopidae,
Trichiuridae,	Caristiidae,	Banjosidae,
Emmelichthyidae,	Oplegnathidae,	Histiopteridae,
Aplodactylidae,	Cirrhitidae,	Sillanginidae,
Labridae,	Antigonidae,	Hepatidae,
Ostraciidae,	Veliferidae,	Trachypteridae,
Regalecidae,		

d.) The families restricted from the northern fisheries off Kushiro, Hokkaido.

Lamnidae,	Cetorhinidae,	Rhinochimacridae,
Pterothrissidae,	Synaphobranchidae,	Tetragonuridae,
Trichothontidae,	Plagiodontidae,	Myctophidae,
Erilepidae,	Anoplopomatidae,	Hexagramunidae,
Cyclopteridae,	Liparidae,	Blennidae,
Notacanthidae,	Stichaeidae,	Bathymasteridae,
Cryptacanthoidae.		

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Studies on the Fish Fauna at the Southern Vicinity of Tsu City, Mie Prefecture

Supplemental Note—I.

(*With 1 Table*)

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In the previous paper (1956) we described 56 species composing of the fish fauna at the southern vicinity of Tsu City, extending 1952 to 1956. Two fishes collected newly in this area after that are added and the distributing range of four species is amplificated.

The additional species are as follows:

57) *Liza haematocheila* (Jordan et Schlegel). " Menada ",--marine fish- *cf.* (2) p. 103, pl. 41, fig. 1. Single specimen was captured by a casting net at Station X, December 1956. It is more than probable that this fish had intermingled into true mullet (*Mugil cephalus*) which were collected by a four armed drop net at Station I and stocked into this irrigation draining way. Consequently the fish will probably distribute at Station I.

58) *Eleotris pisonis oxycephala* (Temminck et Schlegel), " Kawa-Anago ". —fresh and brackish water fish—Many numbers of this young goby were taken in the " Sengan " and the other brackish regions, October to November, 1956. They had mainly swum the mid layer of bottom cespitosed of the "Ko-Amamo" " Ajimo " at low tide. The adult specimens had not yet collected from whole area.

The amplification of distributing range are as follows:

1) *Konosirus punctatus* (Temminck et Schlegel). Several specimens of this fish were collected in irrigation draining way (Station X), and consequently the mark in Table 2 of the previous paper must revise from ± to + (Table 1)'

10) *Acheilognathus lanceolata* (Temminck et Schlegel). The numerous specimens were collected at Stations XII and XIII, and a few was taken at Station X, September to November, 1956. The mark + was added to each item of Stations X, XII and XIII in Table 2 of the previous paper (Table 1).

33) *Shiganus fuscescens* (Houttuyn). A fisher man of our awuaintance was stung by dorsal spines of this young fish at Station X, September. The several specimens were collected at Station X′, October 1956. The mark ± was added to the items of both Stations X and X′ in Table 2 of previous one (Table 1).

45) *Gobius abei* Jordan et Snyder. This goby is a collecting oversight and lives in the brackish waters of this area. They were very abundantly collected at Stations I to III, V, X′ and XI from September to November 1956. In Table 2 of previous paper, the mark must revise from ± to + the item of Station I and must add + to each item of stations mentioned above (Table 1).

The additions and revisions in Table 2 of previous paper were shown into the following Table.

Table 1

Fish name	Station								
	I	II	III	V	X	X′	XI	XII	XIII
Liza haematocheila	±				±				
Eleotris pisonis oxycephala	+	+	±	±	±	+	+	±	
Konosirus punctatus					(+)				
Acheilognathus lanceolata					+			+	+
Shiganus fuscescens					±	±			
Gobius abei	(+)	+	+	+		+	+		
Common collections	31	15	12	7	18	17	15	16	15
Rare collections	7	14	9	9	8	13	2	7	5
Total	38	29	21	16	26	30	17	23	20

The additions and revisions in Table 3 of previous paper were as follows: Additional species, *Liza haematocheila* (IX) and *Eleotris pisonis oxycephala* (I); revisional species, *Shiganus fuscescens* (IX→VIII) and *Gobius abei* (IX→V).

References

(1) OKADA, Y. and S. S. KUBOTA 1956. Studies on the Fish Fauna at the Southern Vicinity of Tsu City, Mie Prefecture, Rep. Fac. Fish., Mie Pref. Univ., Vol. 2 No. 2, pp 205-216.

(2) OKADA, Y., K. UCHIDA and K. MATSUBARA 1935 A Figure of Japanese Fish, Tokyo and Osaka.

Errata of the Previous Paper (Rep. Fac. Fish. Uni. Mie, Vol. 2, No. 2)

Page	Line	Error	Correct
214	21	"Ajimo"	"Amamo", *Zostera marina* L.,
216	13	blackish	brackish

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Note on Rare Lantern-fish, *Diaphus sagamiensis* Gilbert from Kumano-nada, Japan

(*With 2 figures and 1 Table*)

Yaichiro OKADA and Koichiro MORI

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In 1913, Charles H. Gilbert published the original description of the present species based on the specimen (67 mm. in total length) collected from Sagami Bay, Japan. Ever since, any specimen of the present species has not been collected in any water of the world. In December, 1956, we had a chance to collect large number of specimen of fish from deep-water off Owashi, Mie Prefecture, Japan. Among these specimen, a rare lantern-fish, *Diaphus sagamiensis* Gilbert which are redescribed in the present paper with additional notes.

Diaphus sagamiensis Gilbert

Japanese name : "Sagami-hadaka"

Diaphus sagamiensis Gilbert, Memoirs of the Carnegie Museum, vol. VI. no. 2, p. 96–98, pl. XIII, fig. 2, Sagami Bay, Japan.

The present species is 86 mm. in standared length (104 mm. in total length), having fhe following counts and measurements :

D. 15 (including anterior rudiments) ; A 15 ; P. 12 ; V. 9, the outer reduced to a short rudiment. Scales in lateral line 36, the upper SAO on the 19th scale, the POL on the 25th. Gill-rakers 9 (including 2 rudiments)+14 on the 1st arch

Measurements in hundredths of standared length : Head 28 ; snout 3 ; interorbital space 9 ; diameter of eye 8 ; length of maxillary 20; greatest depth (at caudal peduncle) 9 ; distance from tip of snout to origin of dorsal 41, to origin of ventrals 43, to origin of anal 62, to adipose fin 78. Length of pectorals 12, of ventrals 16.

Body rather elongate, its depth 1/5 as long as body length. Snout very short, rounded. Eye large, its length about 3 times as snout. Pre-opercle somewhat oblique. Pectorals very short, not reaching ventrals ; ventrals reaching beyound the vent, inserted under the origin of dorsal. Last dorsal ray little beyond the origin of anal. Last anal ray under the origin of adipose. Scales all fallen. Color in formalin grayish brown throughout, but fins pale. Upper and lower parts of caudal dusky tinged.

Photophores: Small Dn on the orbital margin, above the level of nostril and Vn, which fills the area on the dorsal side of the nostril. Vn narrows, extending beyond the vertical posterior margin of pupil. Suo and So absent.

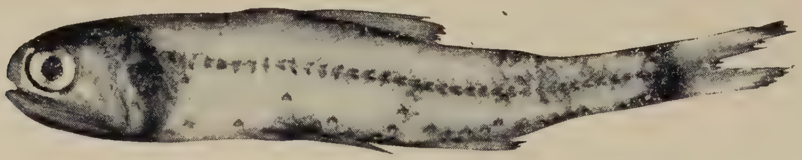

Fig. 1 *Diaphus sagamiensis* GILBERT (×1)

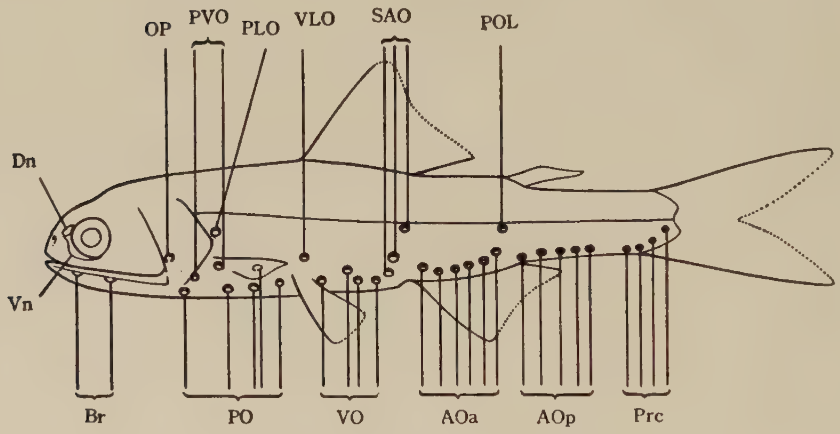

Fig. 2 Photophores arrangement

No photophores above the lateral line. PLO rather high, on over half the midway of the distance between the lateral line and the origin of pectorals. Po 5, the 4th one high and above the base of ventrals. PVO 2, the line joining the two passes on the 1st PO. VLO medially situates between lateral line and origin of ventrals. VO 4, the line joining the 1st and the 2nd ones passes above the 3rd one. SAO 3, arranged in a straight line, the 1st oppositing the vent, above and behind the 4th VO, the 3rd in contact with the lateral line, vertically above the origin of anal. AOa 6 on the left and 5 on the right side, the 1st and the last ones high, in a curved and dented line. POL in contact with the lateral line, above and slightly behind the 6th AOa, vertically above the end of anal base. AOp 5, in a almost straight line. Prc 4, form a gentle curved line rising posteriorly, the last under the end of lateral line.

Remarks: The specimen may be included under the present species, but several slight discrepancies, which are due to the individual variation, from the latter are detected as follows:

	The present specimen	GILBERT's specimen
Standard length	86 mm.	53 mm.
Gill-rakers	9 (including 2 rudiments)+14	8+17
Scales in lateral line	36	35
POL	on the 25th scale of the lateral line	on the 27th scale
Ventral	its tip reaching beyond the vent	not reaching the vent
Color	grayish brown throughout, but fins pale (in formalin)	blackish
AO a	6 on the left and 5 on the right side	6-7

Literature

GILBERT, Charles H. 1913; Memoirs of the Carnegie Museum, vol. VI, no. 2, p. XIII, fig. 2.

BÖHLKE, J. 1953; A Catalogue of the Type Specimens of Recent Fishes in the Natural History Museum of Stanford University, p. 19.

MATSUBARA, K. 1950; Fish Morphology and Hierarchy, part I, p. 257.

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The species of the genus Gelidium from Japan and its vicinity (II)

(With 1 Plate and 3 Text-figures)

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In the previous paper (Rep. Fac. Fish. Mie Pref. Univ. Vol. 2, No. 1, 1955) the writer reported four species of *Gelidium* from Japan and its vicinity.

The present paper deals with the systematic study of its three other species which have hitherto been unreported in Japan. In this paper unsuitable points for determination hitherto performed were corrected by the writer.

Gelidium corneum (Hudson) Lamouroux var. *pulchellum* Greville

Plate XXIV, 1 and Text-fig. 1

Alg. Brit. (1830), p. 144; Turner, Fuci, vol. 4 (1819), p. 149, tab. 257, fig. p; Harvey, Phyc. Brit. vol. III (1846–51), pl. 191; Segi, Spec. of Gelid. from Japan and its vicin. (1) (in Japanese) (Bulle. of Jap. Soc. of Phyc. vol. 2, No. 1. 1954) p. 14.

Japanese name: *Ryūkyūbuto* (nov.)

Hab.: Naha, Ryūkyū. (T. Teramachi).

Distri.: Europe.

The frond is rigid, capillary, compressed and standing from fibrous root. It is about 4–4.5 cm. in height and 0.5–1 mm. in width, 175~195 μ in thickness in the central part of the main axis. It branches in bi-tripinnate manner, densely upwards. The branches are elongated, flexuose and attenuated at each end. The ultimate branchlets are linear, clavate and obtuse at their apices. The medullary cells are aggregated near the central part and almost elliptical in shape, showing various sizes from about $8 \times 6\,\mu$ (smallest) to $24 \times 18\,\mu$ longest). The rhizoidal filaments are aggregated in the lower part of the cortical layer or between the cortical layer and central tissue, being scattered or forming a mass. They are about 4.5 μ in diameter. The cortical cells are forming about 2 layers. They are lumpish in shape and $6 \times 4.5\,\mu$ in size. The tetrasporangia are dotted numerously in the swollen part of the ultimate branchlets. The cystocarps are unknown. The frond is rigid membranaceous in substance and shows dark purplish red in colour.

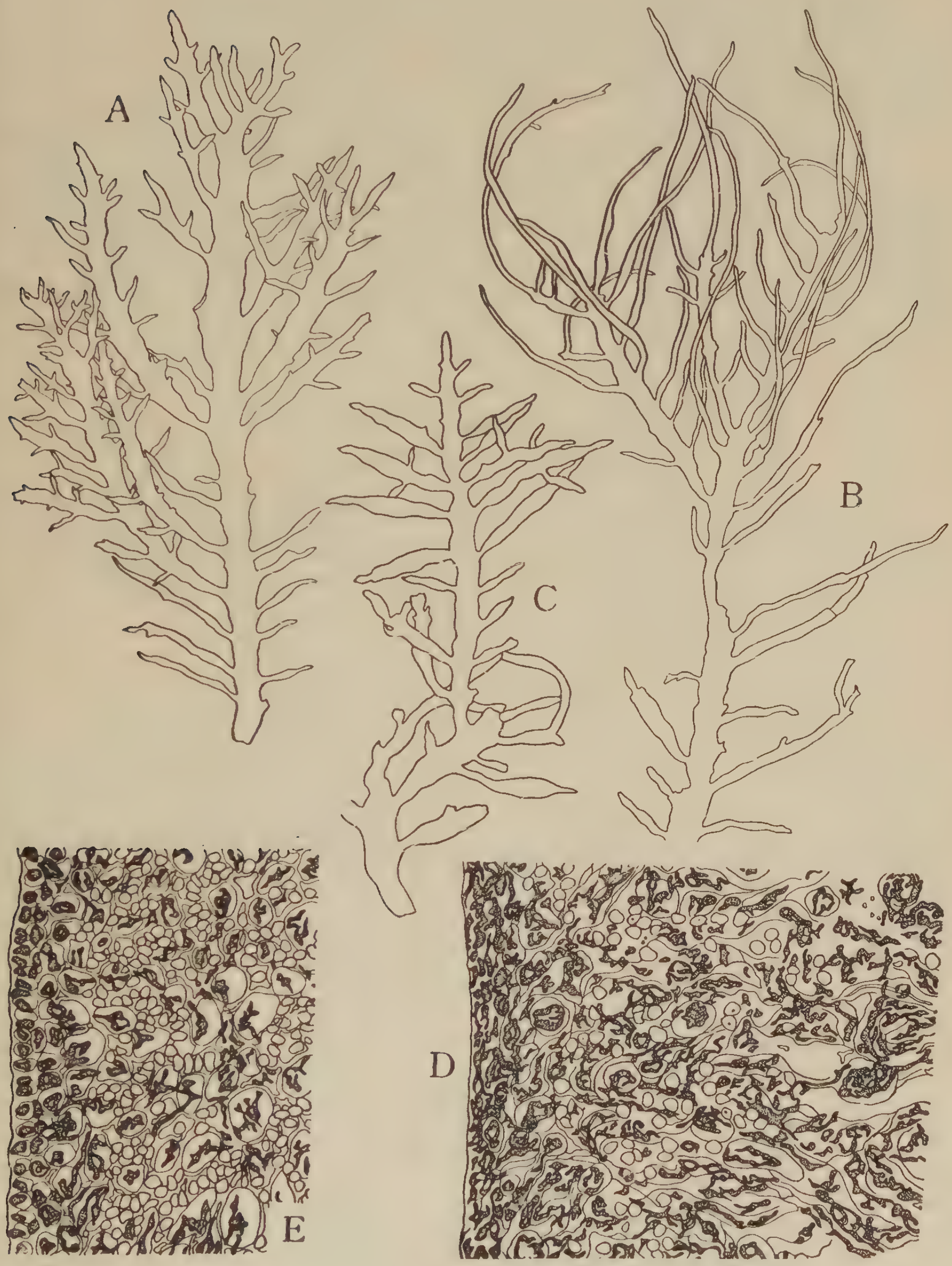

Fig. 1. *Gelidium corneum* (HUDSON) LAMOUROUX
var. *pulchellum* GREVILLE
A. B. C. Branch. ×ca. 7; D. E. Transverse section of the frond. ×400.

The branchlets are often irregularly elongated as shown in Fig. 1, B. The frond is rather fine and rigid in substance.

This specimen agrees well in general with the descriptions and figures given by various authors.

Being compared with foreign specimen (Cherbourg), the present specimen agrees well with it in general. The fronds of the French specimen are capillary and more fine than those of Naha one. On the other hand, the present specimen resembles much to the Australian specimen (Kangaroo Isl., Coll. and Det. Womerseley) of *G. australe* J. AGARDH. On this point the writer expects to study further on.

Gelidium pulchrum GARDNER

Plate XXIV, 2 and Text-fig. 2

New spec. of Gelid. on the Pac. Coast of North Amer. (Univ. Calif. Publ. Bot., vol. 13, 1927), p. 279, pl. 50–53; Segi, Spec. of Gelid. from Japan and its vicin. (1) (in Japanese) (Bulle. of Jap. Soc. of Phyc. vol. 2, No. 1, 1954) p. 14.

Japanese name: *Sasamebusa* (nov.)

Hab.: Kashiwajima, Tosa Prov. (T. Tanaka.)

Distri.: Pacific coast of North America.

The frond is rigid, slender, flattened and standing from fibrous root. It is 7–10 cm. in height, 1.5–2 mm. in width in the middle part, gradually narrowing upwards and branching 5–6 times in a distichous manner. The branches are out alternately or oppositely from somewhat upper part of the base, sometimes fastigiated. It is elongated, flexuose, slightly narrow at the base, issuing many short, spinous ultimate branchlets in alternate or opposite or irregular manner on both sides, acute at the apices. The medullary cells are scattered round or elliptical, about $15 \times 12\ \mu$. The rhizoidal filaments are aggregated between the cortical layer and the central tissue, about $4.5\ \mu$ diam. The cortical layer is composed of 1–(2) layers, forming lumpish cells. The tetrasporangia are scattered over the short, ultimate branchlets and divided in a cruciate manner. The cystocarps occur in the short, acute ultimate branchlets. It represents purplish red or pink in colour.

The present species is a beautiful and rather slender species of *Gelidium*.

The present species agrees well with the description and figure (pl. 50, 52) given by Gardner in 1. c. But there is one discrepancy between the foreign specimen and Japanese one. Namely, the frond of this Japanese specimen is almost flattened throughout the frond, instead of cylindrical frond in the lower part of it as noted by Gardner.

Being compared with Mexican specimens (Baja Calif., Coll. E. Y. Dawson,

Fig. 2. *Gelidium pulchrum* GARDNER
A. Branch. ×ca. 7; B. Stichidium. ×54; C. Transverse section of the frond. ×400.

No. 144 and 1162 ; Mexico, Det. Cooper No. 820), the specimens at hand agree with them in general. But in those foreign specimens fronds are almost compressed or flattened in the main filaments.

Gelidium pyramidale GARDNER

Plate XXIV, 3 and Text-fig. 3

New spec. of Gelid. on the Pac. Coast of North Amer. (Univ. Calif. Publ. Bot., Vol. 13, 1927), p. 273, pl. 36, pl. 37, fig. 1, pl. 45, pl. 46, fig. 2 ; Segi, Spec. of Gelid. from Japan and its vicin. (1) (in Japanese) (Bulle. of Jap. Soc. of Phyc. vol. 2, No. 1, 1954), p. 15.

Japanese name : *Nagatobusa* (nov.)

Hab.: Shimonoseki and Chōfu, Nagato Prov.

Distri.: Pacific coast of North America.

The frond is rigid and complanate. It is 5.5-7 cm. in height, 1-1.5 mm. in width in the central part, gradually tapering on each end and branching a few times in a distichous manner. The branches are out alternately or oppositely near the base. It is straight or flexuose, narrow or constricted at the base, issuing many linear, blunt, ultimate branchlets in opposite, alternate, or irregular manner on both sides. The medullary cells are scattered, round or elliptical, about $18 \times 15\mu$, having thick cell membrane. The rhizoidal filaments are aggregated between the cortical layer and the central tissue, about 4.5μ diam. The cortical layer is composed of 2 layers, forming rather roundish cells. The tetrasporangia are aggregated at the elongated ultimate branchlets and divided in a cruciate manner. The frond is rather rigid cartilaginous in substance and represents reddish purplish grey in colour.

The present specimen agrees well with the description and plates given by original author. It is characterized by possessing pyramidal outline of the frond and grey colour. The ultimate branchlets are very slender, elongated linear and not pastulate as seen in other species of *Gelidium*.

The specimen (Ryūkyū, col. T. Kuroiwa) in Herb. Okamura (noted *G. latifolium* ?) is perhaps related to *G. pyramidale*. The anatomical character is very close to each other.

Being compared with American specimen (Allan Hancock Foundation, Det. Cooper), this specimen agrees well with it in general. The American specimen is very fine and represents purplish grey in colour as seen in Japanese one.

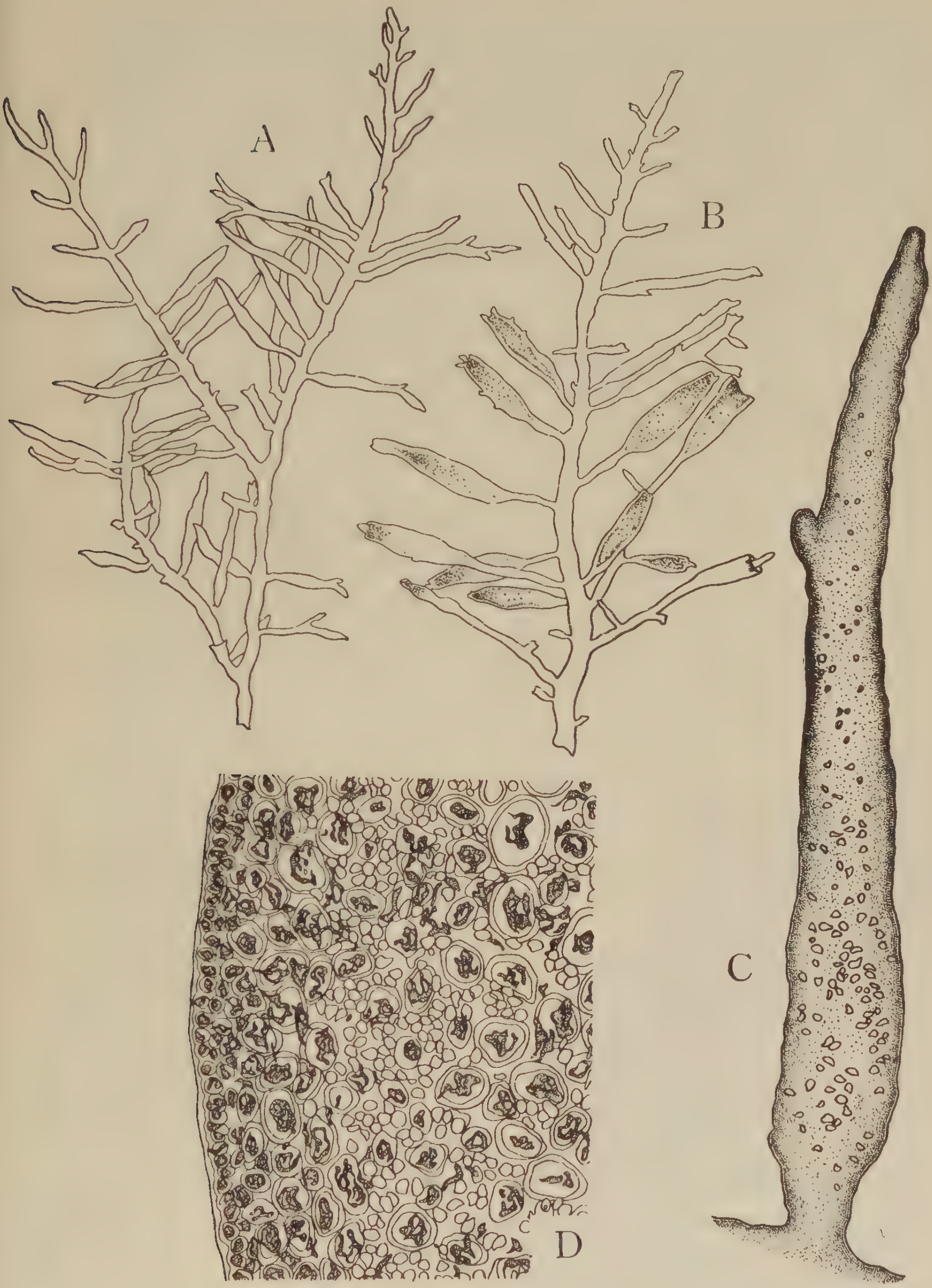

Fig. 3. *Gelidium pyramidale* GARDNER
A. B. Branch. ×ca. 7; C. Stichidium. ×54; D. Transverse section of the frond. ×400.

Explanation of the Plate XXIV

1. *Gelidium corneum* (HUDSON) LAMOUROUX var. *pulchellum* GREVILLE (Specimen from Naha) xca. 1.
2. *Gelidium pulchrum* GARDNER (Specimen from Kashiwajima) ×ca. 1.
3. *Gelidium pyramidale* GARDNER (Specimen from Chōfu) ×ca. 1.

1

2

3

Report of Faculty of Fisheries,
Prefectural University of Mie,
Vol. 2, No. 3, July 30, 1957.

A New Cyclypoid Copepod from Brackish-Water Fish Ponds in Mie Prefecture, Japan

(*With 22 Text-figures and 1 table*)

TAKASHI ITO

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Prefectural University of Mie

About two hundred of eel-culture ponds are located along the western coast of the Ise Bay in Mie Prefecture, the middle of Japan. These brackish-water ponds contains considerable salts (Cl 0.2–8 $^0/_{00}$). During my studies on the plankton fauna in these ponds, I have obtained numerous specimens of the two species of *Acartia*, *A. iscana* and *A. tsuensis* (ITO, 1956), and a rare species, *Apocyclops japonensis* n. sp. included under the genus *Apocyclops* of the Cyclopoid Copepoda.

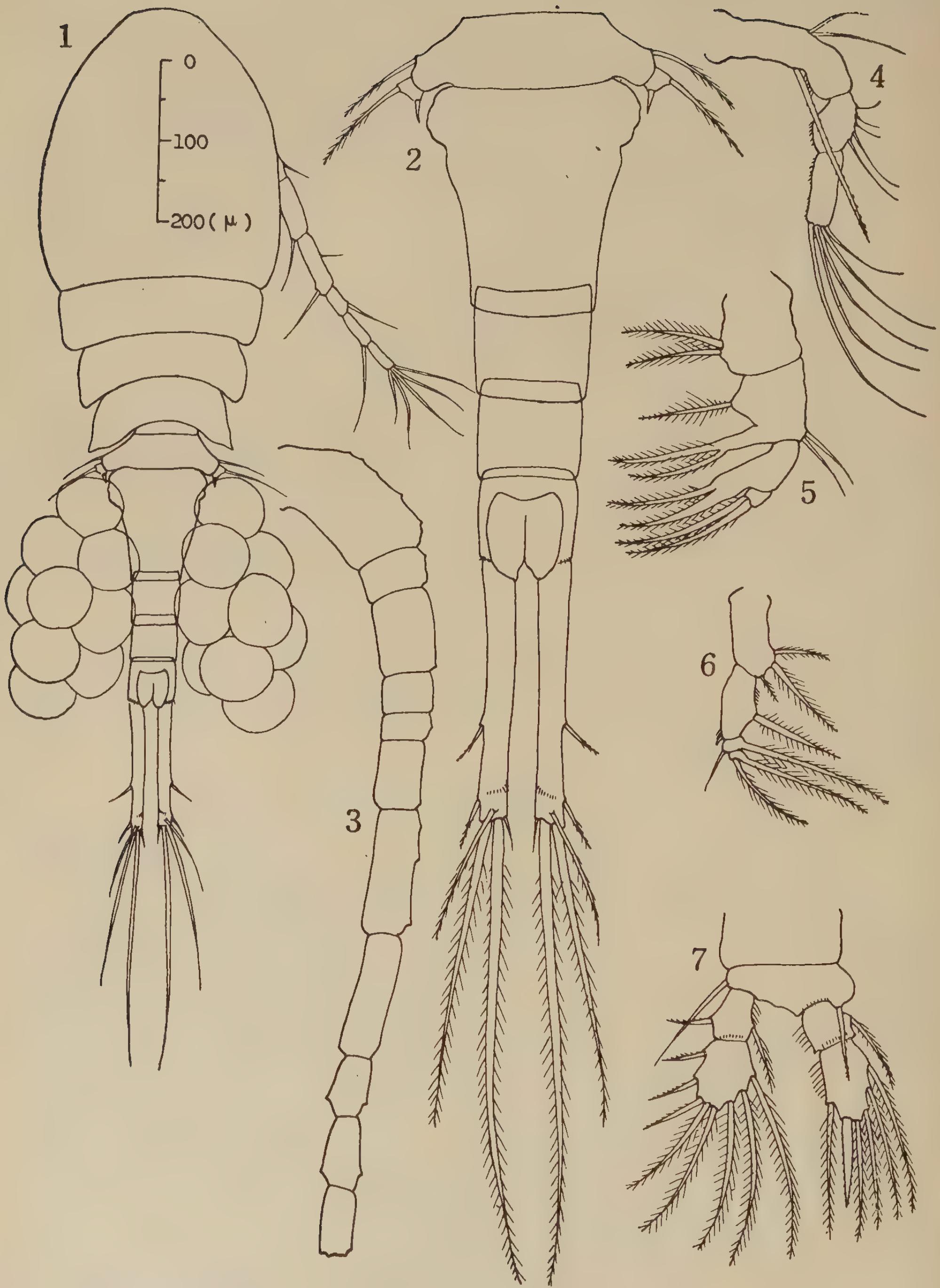
Before going further, I wish to express my thanks to Dr. YAICHIRO OKADA, Dean of the Faculty of Fisheries, Prefectural University of Mie and Dr. MASUZO UÉNO of the Otsu Hydrobiological Station, Kyoto University, for their kind advice on many matters.

Apocyclops japonensis sp. nov.

(Figs. 1–22)

Female : Length 1.006 mm., not including furcal setae. Body yellowish-brown in colour, and moderately short and shout, with the anterior division oval in general outline ; greatest width slightly exceeding half of the length and occurring about in the middle. Cephalic segment very large and somewhat truncated in front, almost twice the length of the 3 succeeding segments combined. Lateral parts of the penultimate thoraxic segment terminating in a short tooth-like projection turned somewhat outwards. Last thoraxic segment broadly rounded laterally, and with a transverse row of spinules on the ventral surface. The posterior division nearly equal to the length of the anterior division ; genital segment dilated in front, about as long as the length of the 3 succeeding segments combined, and gradually narrowed behind (Figs. 1–2).

Furcal rami long and slender, exceeding in length a little the last 3 abdominal segments combined, about 10 times as long as wide ; being nearly linear in form, nearly parallel in direction ; without a longitudinal keel on the dorsal surface ; and both inner and outer margins without hairs ; bearing an oblique row of spinules from the base of the outermost furcal seta towards the inner



Figs. 1–7. *Apocyclops japonensis* sp. nov. female
1. Female (dorsal)
2. Abdomen and furca (dorsal)
3. First antenna
4. Second antenna
5. Second maxilla
6. Maxilliped
7. Leg 1

edge on the ventral surface of furcal rami ; lateral seta very slender, located at distal 1/3 ; outermost seta moderately slender, and attached far from the apex ; inner mediate seta about twice as long as the furcal rami ; outer mediate seta moderately longer than the corresponding rami ; innermost seta conspicuosly small and shorter than the outermost one (0.8:1) ; dorsal seta considerably long, 2.8 times as long as the outermost seta, though much shorter than the outer mediate seta. Lengths of furcal setae in the type spicemen as follows (from inner to outer and dorsal) : 26 : 310 : 211 : 36 : 99 (μ). (Figs. 1-2)

First antenna consists of 11 segments, moderately long and stout, reaching, when reflexed, almost to the posterior end of the 3rd thoraxic segment, and without hyaline membrane on the distal segments (Figs. 1 and 3). Second antenna consists of 3 segments, segment 1 markedly slender, and moderately longer than the length of the 2 succeeding segments combined, with a stout spine on inner margin and 2 small setae on outer side ; segment 2 with 5 small setae along the outer margin, and coarsely serrated with small spinules on the inner margin ; segment 3 a little longer than the penultimate one, and 3 times as long as wide, with 5 slender setae on the top, and with spinules on the proximal and distal parts of the inner margin (Fig. 4). Mandible rather small, consists of the usual structure. First maxilla moderately simple, terminating in 5 tooth-like projections on the top. Second maxilla moderately large, as shown in Fig. 5. Maxilliped rather small, as shown in Fig. 5.

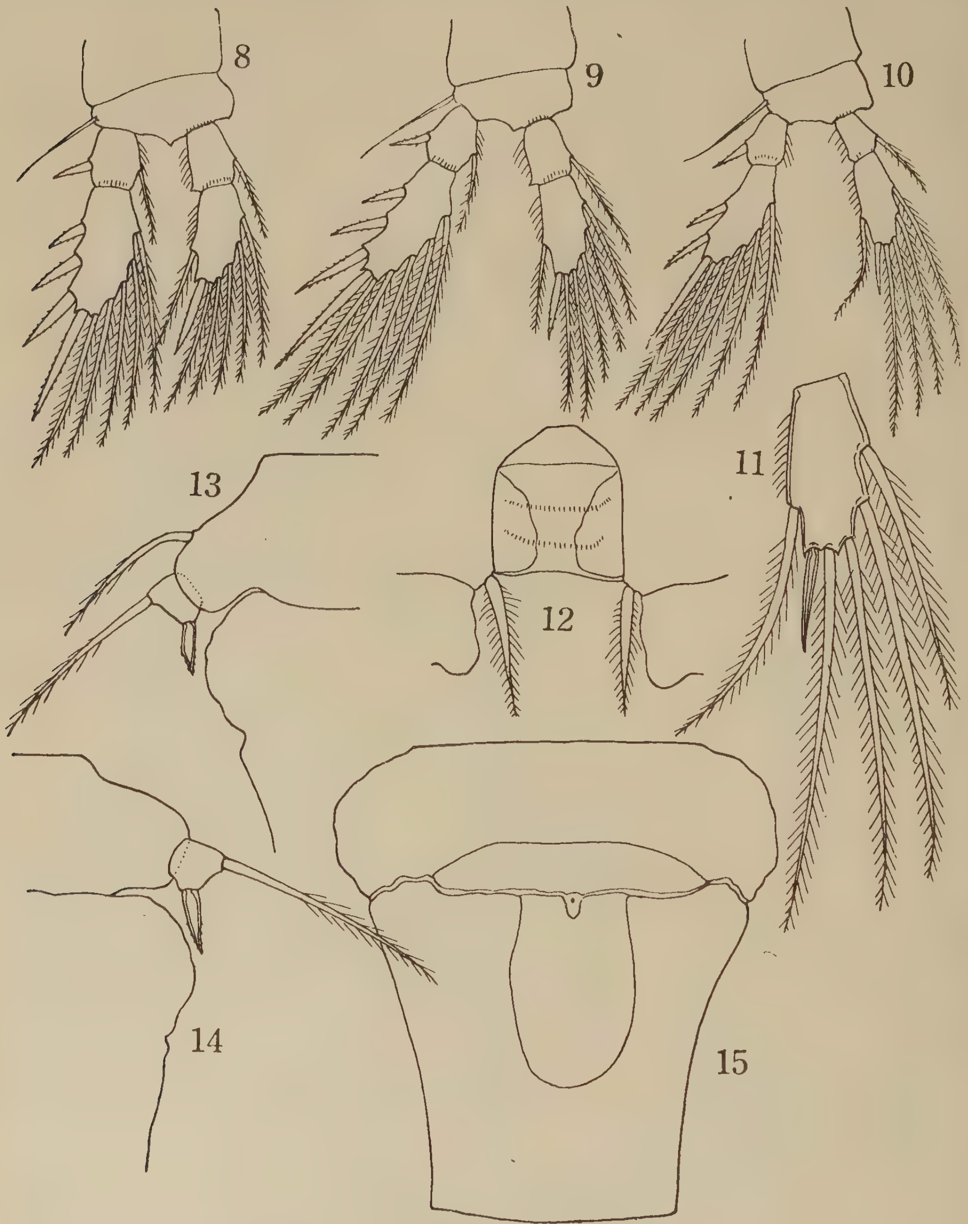
Legs 1-4 with formula 2,2/2,2/2,2/2,2 ; spine-formula in exopodite 3,4,4,3 ; seta-formula in exopodite 5,5,5,5 ; spine-formula in endopodite 1,1,1,1 ; seta-formula in endopodite 5,6,6,5. The natatory legs comparatively slender, and terminal segments of both inner and outer rami in all pairs unusually prolonged, nearly twice as long as the 1st segment, Leg 1 with a long spine on the inner corner of the second basal segment. Leg 4 without inner seta on the 1st segment of the outer ramus ; terminal segment of the endopodite moderately slender, and about twice as long as wide, with a small outer spine and a long inner seta on the apex ; outer apical spine rather short, 33 μ in length, inner apical seta markedly slender, about 4 times as long as the length of the outer apical spine (Figs. 7-11).

Connecting plate of leg 4 as shown in Fig. 12, moderately simple, with 2 transverse rows of denticles.

Leg 5 very characteristic, segment 1 completely fused with the last thoraxic segment, and outer seta attached on a small protubearance of the last thoraxic segment ; segment 2 rather broad, a half as long as wide, gradually broaded behind, with an inner spine and an outer seta, inner spine rather stout, 17 μ in length, and attached at the inner corner, outer seta moderately slender, about 60 μ in length, and inserted at the outer corner far from the inner spine. (Figs.

1–2 and 13–14)

Seminal receptacle as shown in Fig. 15, similar to that of *Mesocyclops leuckarti* (Claus) in general outline, the anterior lobes somewhat narrowed at the



Figs. 8–15. *Apocyclops japonensis* sp. nov. female

8. Leg 2
9. Leg 3
10. Leg 4
11. Endopodite 2 of leg 4
12. Connecting plate of leg 4
13. Leg 5 (dorsal)
14. Leg 5 (ventral)
15. Seminal receptacle

ends, the posterior part exceeding in length about 2/3 of the genital segment.

Ovisacs comparatively large, oval in shape and somewhat divergent, and generally containing 10–13 of ova. (Fig. 1)

Male : Length 0.769 mm., not including furcal setae, moderately smaller and slender than female. Body yellowish white in colour, the anterior division regularly oval in form, greatest width slightly exceeding half the length and occurring about in the middle. Cephalic segment rather large, and somewhat truncated in front, about 1.5 times as long as the length of the 3 succeeding segments combined. Lateral parts of the penultimate thoraxic segment of nearly same appearance as those of the 2 preceding segments. The posterior division moderately shorter than the anterior division of body ; genital segment considerablly dilated in front and gradually narrowed behind, and slightly shorter than the width, almost as long as the length of the 2 abdominal segments combined (Figs. 16–17).

Furcal rami conspicuosly slender, though moderately shorter than that of female, 6.2 times as long as wide, nearly parallel in direction, with an oblique row of spinules on the ventral surface as in female. Lengths of furcal setae in the type specimen as follows (from inner to outer and dorsal) : 20 : 223 : 161 : 25 : 89 (μ). Innermost seta slightly shorter than the outermost one (0.8:1) ; lateral seta inserted at distal 1/3 ; dorsal seta much longer than the outermost one (3.6:1) (Figs. 16–17).

First antenna as shown in Fig. 18. The structures of second antenna, mandible, first and second madillae, and maxilliped similar to those of female. The structure and formulae of legs 1–4 similar to those of female. Endopodite 2 of leg 4 moderately slender, twice as long as wide, with a small outer spine and a slender inner seta as in female, outer apical spine considerably short, 30 μ in length ; inner apical seta 4 times as long as the outer spine (Figs. 19–20).

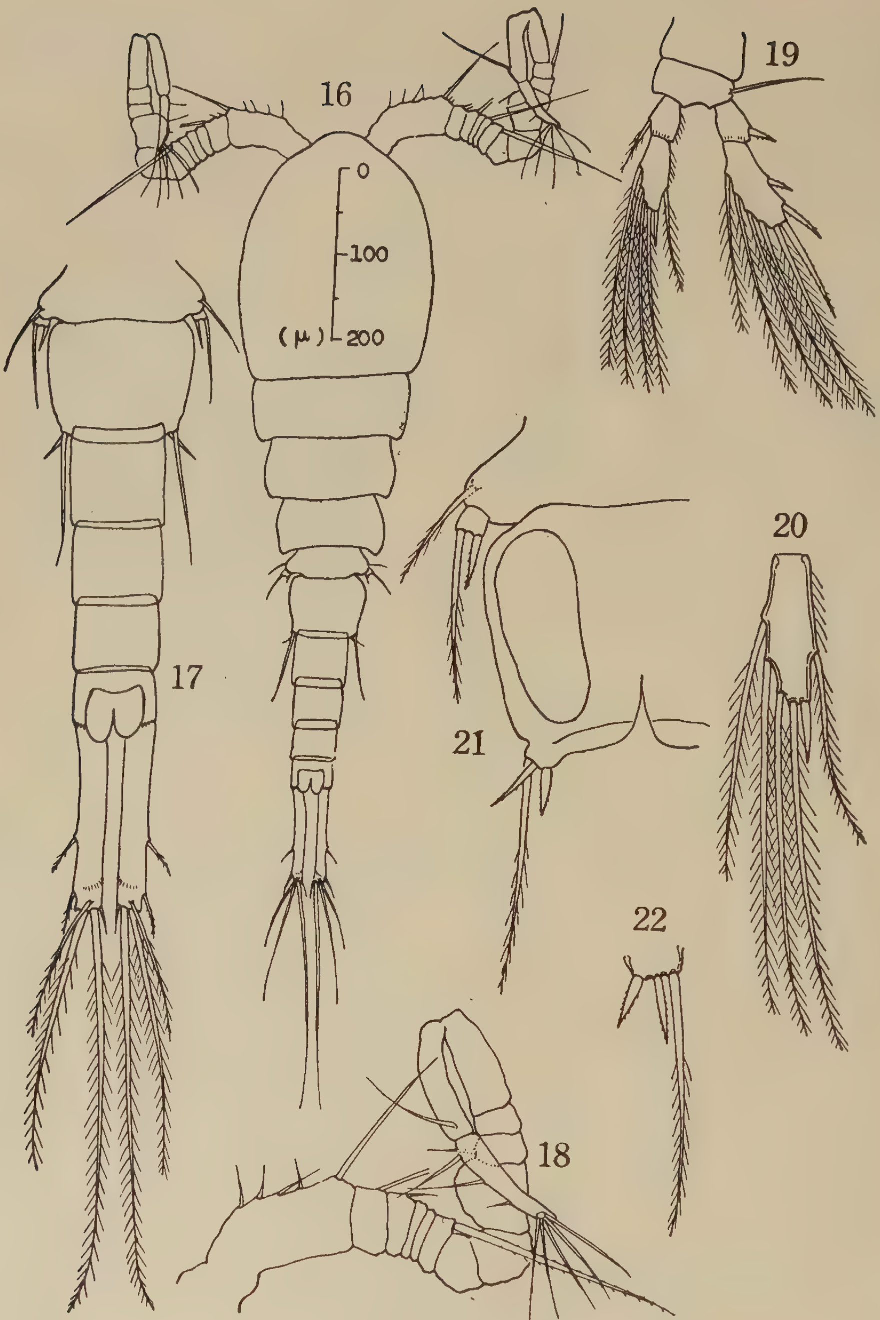
Connecting plate of leg 4, and leg 5 similar to those of female (Fig. 21). Leg 6 as shown in Figs. 21–22, with 2 small inner spines and an outer seta ; outer seta considerably slender, about 5 times as long as the innermost spine, and the mediate spine a little longer than the innermost spine. Lengths of 2 inner spines and an outer seta as follows (from inner to outer): 17 : 20 : 89 (μ).

Type locality : KATO's eel-culture pond in the northern vicinity of Tsu City, Mie Prefecture, middle Japan. The eel-culture ponds (Cl 3.64–6.58 ‰) belongs to the mesohaline brackish-water.

Holotype : Female ; allotype ; male ; the types are preserved in the Faculty of Fisheries, Prefectural University of Mie, Tsu City, Japan.

Variation : The individual variations in the specimens collected from the type locality in some taxonomic characters are as shown in appendix table.

Habitat : I found this new species in two different ponds described below.



Figs. 16–22. *Apocyclops japonensis* sp. nov. male

16. Male (dorsal)
17. Abdomen and furca (dorsal)
18. First antenna
19. Leg 4
20. Endopodite 2 of leg 4
21. Leg 5 and leg 6 (ventral)
22. Leg 6

The one is KATO's No. 3 eel-culture pond, about 1 m. in depth, 3–X–1955 (Cl 6.58 ‰, transparency 29 cm., water-colour brownish yellow, W.T. 24.0° C, pH 7.4, dissolved oxygen 2.4 cc/L (39.6%), alkalinity 4.59 milliequiv./L). The other is KATO's No. 2 eel-culture pond, about 1 m. in depth, in the same locality, 23–IV–1956 (Cl 3.64 ‰, transparency 11 cm., water-colour deep green, W.T. 16.0° C pH 7.4, dissolved oxygen 5.3 cc/L (77%), alkalinity 1.19 milliequiv./L). This new species was accompanied by other brackish-water copepods, *Sinocalanus tenellus* (KIKUCHI), *Pseudodiaptomus inopinus* BURCKHARDT and *Paracyclopina nana* SMIRNOV, also the rotifers, two fresh-water and a brackish-water forms, *Brachionus quadridentatus* HERMANN, *Br. urceolaris* O.F. MÜLLER and *Keratella cruciformis* var. *eichwaldi* (LEVANDER) in the latter pond, and by another brackish-water rotifer, *Brachionus plicatilis* O.F. MÜLLER in the former pond.

Remarks: The present new species is allied to *Apocyclops borneoensis* described by LINDBERG (1954) from a swamp in the tidal zone on the sea shore of Tarakan, Borneo. It is, however, evidently distinguishable from *borneoensis* by the more slender furcal rami, the more separated furcal rami and the more larger body.

References

ITO, T., 1956: Three New Copepods from Brackish-water Lakes of Japan. Pacific Science, Vol. 10, pp. 468–473.

LINDBERG, K., 1954: Cyclopides (Crustacés copépodes) d'iles du Pacifique Sud (Mélanesis et Micronésie) et de Bornéo. Kungl. Fysiografiska Sallskapets I Lund Rorhandlinger, Bd. 24, Nr. 18, 1–14.

Appendix: Table of measurement

Apocyclops japonensis sp. nov.

Length mm.	Furca len. : bre.	Furcal setae in. ou.dor.	Endop. 2 of leg 4 len. : bre	End. 2 of leg 4 inn. se. : out. sp.
♀1.079*	168:17μ=10.2:1	26:310:211.36:99μ	56:26μ=2.1:1	122:30μ=4.1:1
〃 1.042*	165:17 =10.0:1	26:310:223:33:99	53:26 =2.0:1	116:33 =3.5:1
〃 1.066*	172:17 =10.4:1	26:310:211:36:99	56:26 =2.1:1	122:33 =3.7:1
〃 1.017*	172:17 =10.4:1	30:298:211:36:92	56:23 =2.4:1	116:33 =3.5:1
〃 1.004	158:15 =10.6:1	23:285:186:33:86	56:23 =2.4:1	109:30 =3.7:1
♂0.769	102:17 = 6.2:1	20:223:161:25:89	40:20 =2.0:1	119:30 =4.0:1
〃 0.794	106:17 = 6.4:1	23:223:149:26:92	40:20 =2.0:1	116:26 =4.4:1
〃 0.769	109:17 = 6.6:1	23:223:161:26:83	40:20 =2.0:1	106:30 =3.6:1
〃 0.756	106:17 = 6.4:1	20:236:161:26:92	40:20 =2.0:1	109:30 =3.7:1
〃 0.769	106:17 = 6.4:1	20:223:149:23:86	43:20 =2.2:1	116:30 =3.9:1

* : with egg-sacs.

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Content of the Myosin Fraction in Fish Muscle

(*With 1 Table*)

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In Japan, there are fish meat jellies known as "Kamaboko and so on" which have been appreciated by people for a long time. When fish meats are ground together with sodium chloride there produces a visco-elastic paste. The jelly is prepared by heating the paste which has molded on a certain shape. This food has a characteristic elasticity which is known as "Ashi" in Japan. The elasticity, no doubt, is caused by proteins of the meat, and it was reported by HIRANO[1] and KITABAYASHI[2] that the myosin fraction has a bearing on the elasticity. However, since there was no report regarding the myosin content of various fish and its relation with elasticity of fish meat jellies, the authors intended to clarify these problems. As mentioned above, in manufacturing fish meat jellies sodium chloride is added to meat, so the method of DYER *et al.*[3] was used for the estimation of the myosin fraction in this experiment. It is said however, that myosin and actomyosin in fish meats are not of quite same kinds as those in rabbit[4)5)], and that the protein, which is extracted by this method, is a mixture of myosin and actomyosin containing some materials as tropomyosin[6)], carbohydrates, lipids and others[3)]. Recently, it was reported by SAITO *et al.*[7)] that the myosin fraction extracted from fish muscle after the disappearance of ATP mostly consisted of actomyosin.

The results of the experiment showed that a certain relation exists between content of the myosin fraction in the fish meats and the generally known elasticity of the fish meat jellies prepared from the meats.

Experimental

I. Material and Methods :

All of the fish in the experiments had been caught in winter and, those of Nos. 1–7 had been refrigerated for one month to three, and Nos. 8–21 were fresh fish of post rigor.

Procedure for extraction of myosin fraction and soluble protein :

Muscle tissue 25 g. was blended 3 to 5 minutes with 500 ml. of extractant solution containing 5 per cent sodium chloride and about 0.002 M $NaHCO_3$ to give a pH of 7 to 7.5, and using the buffle plate to prevent foaming. The salt solution

was stored slightly below 0° C. to give a final temperature after blending of not over 5° C. The mixture was centrifuged 30 minutes at 2000 to 3500 r. p.m.

1). Myosin fraction was determined on 10 ml. of the supernatant extract by adding 90 ml. of distilled water at 0° C. After standing 4 to 24 hours in the refrigerator, the precipitated myosin gel was centrifuged off by spinning 30 minutes at about 3000 r.p.m. and washed with diluted solution (1:9) of protein extractant solution at 0° C. After pouring off the supernatant, the myosin is dissolved in a few ml. of N NaOH, made up to volume and the nitrogen content determined by the microkjeldahl method.

2). Soluble protein nitrogen was determined on an aliquot of the supernatant solution, by the difference between total nitrogen and nonprotein nitrogen determined by the microkjeldahl method. Nonprotein nitrogen was estimated by precipitation of the protein in 20 ml. of the supernatant solution in 5 per cent trichloroacetic acid and determining nitrogen in the filtrate.

II. Results and discussion :

Table 1 shows the content of the myosin fraction in several fish. It is said that even in the same kind of fish extractability of the protein seems to vary with physiological history of the fish and conditions after the death. Little effect on these points, however, might be found in the results. On the elasticity and the soluble protein, no relation could be found.

There was, however, a distinct relation between the elasticity and the amount of myosin. Of the fish, Nos. 1–3 and 13–21 are known to have a superior elasticity as meat jelly, and Nos. 5–12 are known of inferior one. In the experiments, it was found that the values of myosin/dry matter were large in every fish of Nos. 1–3 and 13–21, and small in Nos. 4–12. Nos. 13 and 19 are said to have a superior elasticity when the freshness is very good, and the low value of No. 13 seems to be caused by denaturation of the meat. It is said that generally in the refrigerated fish the amount of salt soluble proteins decreases[8)–12)], it seems that also in our experiment the values of frozen fish were small. Thus, it was proved that when the fish contains large amount of myosin the jelly prepared from it will indicates a superior elasticity.

Summary

1. Content of the myosin fraction in the muscle of various fish was investigated by the method of Dyer *et al.*

2. In those fish which are known to have a superior elasticity as meat jelly, high content of the myosin fraction was found, while in those of inferior one, low content was found.

Table 1. Content of the myosin fraction in the muscle of various fish.

No.	Sample Name	Dry matter %	Soluble protein %	Myosin %	Myosin/ Dry matter %	Myosin/ Soluble protein %	Soluble protein/ Dry matter %
1	*Nibea argentata* (HOUTTUYN)	19.22	15.46	9.97	51.89	64.48	80.47
2	*Pseudosciaena manchurica* (JORDAN *et* THOMPSON)	18.96	13.47	9.97	53.37	74.02	72.09
3	*Ilisha elongata* (BENNET)	20.40	16.31	8.22	40.31	54.08	79.99
4	*Muraenesox cinereus* (FORSKAL)	22.08	11.15	8.38	37.98	75.17	50.52
5	*Trichiurus japonicus* TEMMINCK *et* SCHLEGEL	29.95	8.00	2.62	8.76	32.78	26.73
6	*Dasybatus akajei* (MÜLLER *et* HENLE)	18.57	5.58	2.27	12.25	40.76	30.05
7	*Cololabis saira* (BREVOORT)	30.14	14.37	6.97	23.14	48.52	47.69
8	*Cypselurus agoo** (TEMMINCK *et* SCHLEGEL)	28.82	17.43	9.90	33.68	55.66	60.50
9	*Limanda angustirostris* KITAHARA*	20.42	13.20	6.99	34.26	52.97	64.68
10	*Thynus orientalis* TEMMINCK *et* SCHLEGEL	23.27	15.55	8.90	38.24	57.23	66.60
11	*Scomber japonicus** (HOUTTUYN)	22.29	16.66	6.23	27.95	37.40	74.74
12	*Sardinia melanosticta* (TEMMINCK *et* SCHLEGEL)	23.92	14.93	6.60	27.59	44.20	62.44
13	*Sepia esculenta* HOYLE	26.53	16.40	9.64	36.34	58.78	63.03
14	*Mustelus manago* BLEEKER	24.34	14.38	9.99	41.07	69.48	59.10
15	*Scombrops boöps* (HOUTTUYN)	23.90	15.31	14.62	61.19	95.48	64.08
16	*Lateolabrax japonicus* (CUVIER)	20.42	16.65	12.80	62.68	76.87	81.53
17	*Trachurus japonicus* (TEMMINCK *et* SCHLEGEL)	24.03	15.83	11.15	46.42	70.40	65.87
18	*Sebastiscus marmoratus* (CUVIER *et* VALENCIENNES	20.17	16.73	9.75	49.36	59.50	82.94
19	*Sepioteuthis lessoniana* FÉRUSSAC	22.59	14.95	13.05	55.79	87.42	66.20
20	*Branchiostegus japonicus* (HOUTTUYN)	19.50	16.45	12.31	63.13	74.81	84.39
21	*Epinephelus septemfasciatus* (THUNBERG)	18.44	11.50	11.42	61.95	94.22	62.36

Nos. 1–7: frozen fish, * :very fresh.

Literatures

1. H. HIRANO: *J. Chem. Soc. Jap.*, **63**, 1081 (1942) (Japanese).
2. K. KITABAYASHI: *Bull. Hokkaido Reg. Fish. Res. Lab.*, No. 11, 105, 126, (1954) (Japanese).
3. W. J. DYER, H. V. FRENCH and J. M. SNOW: *J. Fish. Res. Bd. Can.*, **7**, 585 (1950).
4. J. J. CONNEL: *Biochem. J.*, **58**, 360 (1954).
5. G. HAMOIR (1950–1): Cited by M. Dubuisson, "Muscular Contraction" p. 52, Illinois, C. Thomas Pub. (1954).
6. G. HAMOIR: "Advances in Protein Chemistry", X, 255 (1955), New York, Academic Press.
7. K. SAITO, T. HIDAKA and K. TAKADA: *Abst. Meeting Jap. Soc. Sci, Fish* (in October, 1956) (Japanese).
8. J. M. SNOW: *J. Fish. Res. Bd. Can.*, **7**, 599 (1950).
9. W. J. DYER: *Food Res.*, **16**, 522 (1951).
10. O. E. NIKKILÄand R. R. L INKO: *Food Res.*, **19**, 200 (1954).
11. H. L. SEAGRAN: *Food Res.*, **21**, 505 (1956)
12. R. M. LOVE: *Nature*, **178**, 988 (1956).

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伊勢湾西岸養鰻池の塩分とプランクトン動物相[1)]

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Chlorine Contents and Plankton Fauna of Eel-culture Ponds on the West Coast of Ise Bay

(*With 9 Plates, 5 Text-figures and 9 Tables*)

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Résumé

1) This study is resulted from the researches in 239 brackish-water fish ponds, chiefly in eel-culture ponds distributed in the large area along the west coast of Ise Bay, Mie Prefecture, middle Japan, during September, 1953 to December, 1954.

2) The eel-culture ponds are located along the west coast-line of Ise Bay, ranging from northward Isoshima down to Anagawa; the central places are Jonan, Kawagoe, Kusu, Tsu, Karasu and Matsusaka. (Fig. 1).

3) These brackish-water fish ponds, with no exception, containing salt to some extent, belongs to the category of "brackish-water". The salinity of the pond water is Cl 0.232‰ in its minimum, and 12.928‰ in its maximum; those ponds of Cl 1–2‰ are the most, 40% of all, and those of Cl 2–3‰ come to the next amounting to 23%. But about 10% of all ponds which contain Cl 5–8‰ are practically used for eel-culture. The salinity of these pond waters in Mie Prefecture is, compared with that of those in Shizuoka and Aichi prefectures, conspicuously high. (Table 1 and Fig. 2).

4) The zooplankton in these brackish-water fish ponds is composed of the three elements—marine, brackish-water, and fresh-water forms; and in these forms, the latter two forms were dominate in kind and quantity.

5) As the marine zooplankters are found *Acartia spinicauda* GIESBRECHT, *A iseana* ITO, *A. tsuensis* ITO, *Oithona nana* GIESBRECHT, *Ceratium macroceros* (EHRENBERG), *C. furca* DAJARDIN, *Favella ehrenbergi* (CLAPAREDE et LACHMANN) and *Tintinnopsis radix* (IMHOF), but these species are small in quantity.

6) As brackish-water forms, there we found *Sinocalanus tenellus* (KIKUCHI), *Pseudodiaptomus inopinus* BURCKHARDT, *Paracyclopina nana* SMIRNOV, *Neomysis japonica* (NAKAZAWA), *Brachionus plicatilis* O. F. MÜLLER, *Keratella cruciformis* var. *eichwaldi* (LEVANDER), *Testudinella clypeata* (EHRENBERG), *Pedalia fennica* LEVANDER, *Balanus* nauplius larva etc; among them *Sinocalanus*, *Pseudodiaptomus*, *Neomysis*, and *Br. plicatilis* are the most prominent and also rich in quantity.

7) As fresh-water forms are many in species; and those which are widely distributed and dominate in quantity are: *Moina dubia* DE GUERNE et RICHARD,

1) 本研究の1部は夫々日本水産学会総会 (昭30, 4月, 東京), 日本陸水学会総会 (昭30, 5月, 島根), 並びに「鰻のシンポジウム」(昭 30, 3月, 関西) において講演したものである。なお本研究の1部は昭和 29 年度文部省科学研究助成補助金によつたものである。

Brachionus calyciflorus PALLAS, *Br. quadridentatus* HERMANN, *Br. angularis* GOSSE, *Br urceolaris* O. F. MÜLLER, *Keratella valga* (EHRENBERG), etc.; and the other forms, *Mesocyclops leuckarti* (CLAUS), *Thermocyclops taihokuensis* (HARADA), *Cyclops vicinus* ULJANIN, *Alona rectangula* G. O. SARS, *Bosmina longirostris* (O. F. MÜLLER), *Keratella quadrata* (O. F. MÜLLER), *K. conchlearis* (GOSSE), *Filinia longiseta* EHRENBERG, *Polyarthra trigla* (EHRENBERG), *Asplanchnopus syrinx* EHRENBERG, *Ceratium hirundinella* O. F. MÜLLER, *Asplanchna* spp., etc. will be found but not so important in quantity.

8) At the "Mizukawari" time in the eel-culture ponds, a great increase of a fresh-water rotifer, *Brachionus calyciflorus* PALLAS in lower haline ponds (Cl 0.2–3‰), and of that of brackish-water rotifer, *Br. plicatilis* O. F. MÜLLER in higher haline ones (Cl 2–7‰) is recognized. (Table 8)

9) In these brackish-water fish ponds, the zooplankton were composed of 1–10 species, and the compositions of 2–4 species, *Sinocalanus tenellus*, *Pseudodiaptomus inopinus*, *Neomysis japonica* and *Brachionus plicatilis* especially prominent, and it has 50% of all ponds. Furthermore, the number of their species decreases reversely to the salinity of pond water, and the composition of zooplankton becomes simpler. Their plankton fauna, compared with those in fresh-water lakes and in the sea is very monotonous; this indicates the disharmony of the brackish-water fish ponds. (Table 7).

10) There exists a considerably distinct relation between the distribution of zooplankters and the salinity of pond water, and here we'll give a proposition of defining the distribution range (Cl 0.2–17‰) of brackish-water copepods, *Sinocalanus tenellus* (KIKUCHI) and *Pseudodiaptomus inopinus* (BURCKHARDT) as "brackish-water". And this "brackish-water" may be more subclassified with both the limits of Cl 1, 5, 9‰ and the distribution of zooplankters. (Figs. 3, 4 and 5).

11) Accordingly, thorugh the zooplankters and the density of salt in ponds these brackish-water fish ponds may be classified as follows:

		Cl ‰
	Fresh-water	<0.2
I.	Oligohaline brackish-water	0.2–1.0
II.	Mesohaline brackish-water	1.0–9.0
	II a. α–Mesohaline brackish-water	1.0–5.0
	II b. β–Mesohaline brackish-water	5.0–9.0
III.	Polyhaline brackish-water	9.0–17.0
	Sea-water	>17.0

Here, you will find the classification by REDEKE (1922, 1936) the most adaptable to these brackish-water fish ponds.

12) Through the above classification, the 80% of the eel-ponds in culture along the west coast of Ise Bay is proved to be α–Mesohaline brackish-water, Oligohaline and β–Mesohaline brackish-waters respectively amount to 10%, and no fresh- and polyhaline brackish-waters are found among them. (Table 9).

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I. 緒　　論

三重県の伊勢湾西岸には 236 面，130 町歩の養鰻池が存在し，静岡並に愛知両県と共に本邦における養鰻の中心地の 1 つをなしている。これらの養鰻池は海岸近くにあり，例外なく相当量の塩分を含有し，淡水 (Fresh-water) ではなくて，汽水 (Brackish-water) の範疇に属する。池水の含有する塩分量が滲透圧並にその生理作用によつて養殖魚の生理に直接的に影響を与えるのは勿論，またそれが池水の水質，底質或いは池中における物質代謝を決定的付け，プランクトン相とその生産を支配し，これらの生態環境が“水変り”の程度と方向に影響し，その結果として間接的に養魚成績に重要な影響を与えることは容易に考え得ることである。

養鰻池の塩素含有量については，静岡県の池では稲葉 (1937)，愛知県伊川津地方の池では中村 (1948，1949) の研究がある。汽水性養魚池における淡水魚コイ，フナの生理と塩分との関係並にプランクトン植物の生産と塩分との関係については中村 (1948) の注目すべき研究がある。養鰻池のプランクトン動物相については，稲葉 (1934，1936) が静岡県吉田地方の養鰻池から，*Cylops vicinus*, *Leptocyclops* sp., *Alona rectangula*, *Chydorus ovalis*, *Moina weismanni*, *Brachionus bakeri* var. *cluniorbicularis*, *Polyarthra platyptera*, *Triarthra longiseta*, *Br. pala*, *Br. pala* f. *amphiceros*, *Br. urceolaris*, *Rattulus* sp., *Epistylis anastatica*, *Peridinium* sp. を報告し，且つ水変り時には輪虫類の *Brachionus pala* が大発生することを最初に見出した。この発見は高く評価さるべきものである。この水変り時における輪虫類の大増殖は稲葉(幾) (1937) によつて静岡県浜名地方において確認され，更に *Br. pala* 並に *Br. urceolaris* の塩分に対する抵抗性の実験から，これらの輪虫類は Cl 5g/L 以上で死滅することを見ている。

しかし全体的に見ると養鰻池のプランクトン相は不明の点が多く，特にプランクトンの分布と池水の塩分との関係は従来全く明かにされていない。筆者は先ずこの点を明かにするため昭和 28 年 9 月から昭和 29 年 12 月に亘り，三重県全域の養鰻池を限なく廻り，239 面の汽水性養魚池の調査を行い，津附近の 73 面の養魚池のプランクトン動物相に関しては既に発表した (伊藤，1955)。其の後三重県全域の資料も整理が出来たので，伊勢湾西岸における養鰻池を主とする汽水性養魚池のプランクトン動物相と池水の塩分との関係を第 1 報として報告する。

本研究にあたり御指導戴き貴重な文献を貸与された京都大学上野益三教授，並に輪虫

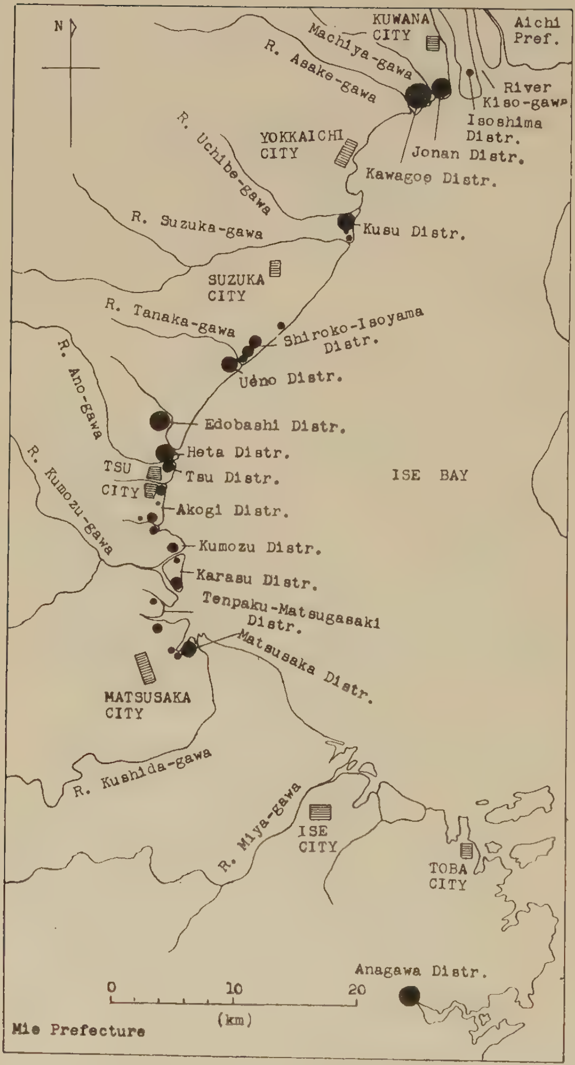


Fig. 1. Geographical distribution of eel-culture ponds on the west coast of Ise Bay, Mie Prefecture, middle Japan.

類について御教示戴いた大津臨湖実験所主任山元孝吉氏に深甚の謝意を表すると共に，養鰻池の研究をすすめられ，種々の助言をあたえられた本学水産学部長岡田弥一郎教授，並に野外調査に協力された本学水産学部岩井寿夫助手に感謝します。なお川越地区の1部の調査に協力戴いた元三重県淡水増殖試験場長井上義雄氏並に所員の方々に謝意を表し，本研究の観測に協力と便宜を与えられた多数の業者の方々に感謝します。

II. 三重県における養鰻池の地理的分布

三重県の養鰻池は Fig. 1 に，明かのように，大部分が伊勢湾西岸の海岸線に膚接している。これらの養鰻池はその分布地域から見て，伊曽島，城南，川越，楠，白子・磯山，上野，江戸橋，部田，津，阿漕，雲出，香良州，天白・松ケ崎，松阪，穴川の 15 地区に便宜上分けることが出来る。最後の穴川地区は，他の 14 地区から不連続であり，志摩地方の的矢湾奥部に位置する。これらの中で更に中心地域は，城南，川越，楠，白子・磯山，上野，江戸橋，部田，香良州，松坂，穴川地区である。

本研究における調査は全域に亘り，殆んどセンサスに近く，養殖中の養鰻池 185 面，養殖休止中の養鰻池 31 面，その他に比較のために天然のボラの養魚池その他 23 面，計 239 面について行つた。

III. 池水の塩素含有量

硝酸銀滴定法により，239 面の各池水について求めた池水の塩素含有量 (Cl ‰) を 1‰

間隔に池の数をプロットして度数分布とし，地域的に示したのが Table 1*) である。池水の塩分は季節により，また年により相当の変動があるが，よく設備され，よく管理された池では，これらの変動はそれ程大きいものではなく，全体的に見ると，池の立地条件，並に個人の管理方式によつて略々定まつている。

今回の調査結果によると，池水の塩素含有量の最小は 0.232‰ (天然池), 0.412‰ (川越, シラス池), 0.440‰ (白子，養鰻池) であつた。最大は 12.928‰ (松ケ崎，天然池), 7.952‰ (白子，養鰻池) で，塩素量 7—8‰ の養鰻池が 7 個見られた。養殖中の 185 面の養鰻池の水について見ると，池水の塩素含有量の状況は Fig. 2 にも明かであるが，下記の通りである。

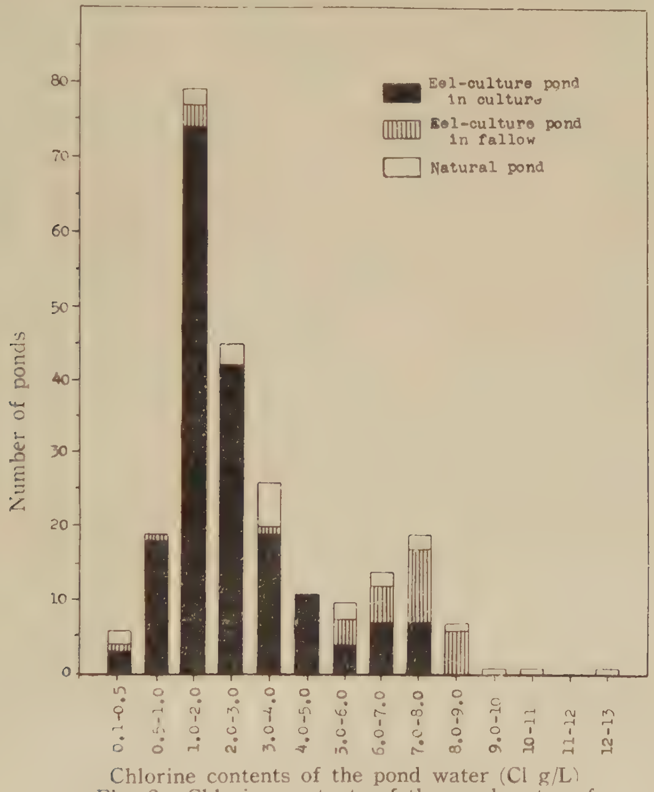


Fig. 2. Chlorine contents of the pond water of brackish-water fish ponds on the west coast of Ise Bay, Mie Prefecture.

池水の塩素含有量 (‰)	池の数	全体に対する割合 (%)
<1	21	11
1～2	74	40
2～3	42	23
3～4	19	10
4～5	11	6
5～6	4	2
6～7	7	4
7～8	7	4
計	185	100%

*) 伊藤 (1955, p. 19) に掲載したが，同表には誤植が多数あつたので，ここに再録することにした。

Table 1. Chlorine contents of the pond water of eel-culture ponds on the west coast of Ise Bay, Mie Prefecture. Middle Japan. The figure in the table shows the number of ponds. bracket-free, eel-culture pond in culture; ( ), natural pond; [ ], eel-culture pond in fallow.

Region	Pond Numbers	Chlorine Contents of Pond Water (Cl ‰) 0.2 ~0.5	0.5~1	1~2	2~3	3~4	4~5	5~6	6~7	7~8	8~9	9 ~10	10 ~11	11 ~12	12 ~13	Date Surveyed
Isoshima	5				2(1)	(1)		(1)								Oct. 16. 1954
Jōnan	20			20												Oct. 17. '54
Kawagoe	46	1	11	19	10	3	1		1							Oct. 19, 28 Nov. 1, '54
Kusu	24		1	14	7	2										Oct. 14. '54
Shiroko・Isoyama	17	1 [1]		2	5	1			2	4(1)						Oct. 12. '54
Ueno	18		1	3(1)	4	3(1)	4				(1)					Oct. 13. '54
Edobashi	17			2	1	5	4	4	1							Aug. 31. '54
Heta	21			2	8	3(1)				[7]						Sep. 20. '53 Jun. 22. '54
Tsu	9			[1]	(1)			[2]	[2]	[3]						Sep. 19. '53
Akogi	10		1	1		[1]	1	[2]	[3]			(1)				Sep. 15. '53
Kumozu	11	1(2)		2	(1)	1(1)	1		(1)	(1)						Sep. 9. '53
Karasu	8		[1]	4 [1]		(1)		(1)								Sep. 6. '53
Tenpaku・Matsugasaki	9			1 [1]	3	(1)			(1)				(1)		(1)	Oct. 21. '54
Matsusaka	14		4	4(1)	2	1			1	1						Oct. 22. '54
Anagawa	10								2	2	[6]					Dec. 10. '54
Total	239	6	19	79	45	26	11	10	14	19	7	1	1	0	1	

Table 2. Salinity of the pond water of eel-culture ponds in Shizuoka, Aichi and Mie Prefectures, Middle Japan. The figure indicates the number of ponds. (from Nakamura 1955)

Prefecture	Region	District	Pond numbers	Chlorine contents of pond water ‰								Date
				<0.1	0.1~1	1~2	2~3	3~4	4~5	5~6	6~7	Mean	
Shizuoka	Kawajiri	Kawajiri	42	42								0.03	Sep. 5~9. 1955
	Fukuda	Fukuda	11			9	1	1				1.85	Oct. 21. '55
	Hamana	Maisaka	17		6	6	2	2	1			1.60	Sep. 16. '55
		Murakusi	24		22	2						0.44	Sep. 16. '55
		Chuo	8	5	3							0.09	Oct. 22. '55
Aichi	Muro	Meiji	7	7								0.05	Oct. 5. '55
		Osaki	8	1	4	1	2					1.04	Oct. 5. '55
		Sango	12		9	2	1					0.78	Oct. 8. '55
		Yongo	12	1	5	5	1					1.08	Oct. 12. '55
		Yoshizaki	4	1	3							0.54	Oct. 12. '55
	Izumi	Izumi	30		4	11	10	5				2.23	Aug. 30. '55
	Hazu	Hazu	13		7	5	1					1.05	Oct. 17. '55
	Hekinan	Hekinan	19		15	3	1					0.78	Oct. 1. '55
Mie	Mie	Jōnan	9			8	1					1.63	Sep. 21. '55
		Kawagoe	17		3	7	4	2	1			1.97	Sep. 21. '55
		Kusu	9				1	4	3	1		3.86	Sep. 22. '55
		Tsu	10				4	3	0	1	2	3.71	Sep. 22. '55

Table 3. Occurrence of plankton crustaceans in eel-culture ponds of varying salinities, Mie Prefecture. The figure in the table shows the number of ponds.
ccc, very abundant; cc, abundant; C, frequent; +, common; r, rare; rr, very rare.

Species	Collected ponds	Chlorine contents of the pond water Cl ‰														Distribution range Cl ‰
		0.1~0.5	0.5~1.0	1~2	2~3	3~4	4~5	5~6	6~7	7~8	8~9	9~10	10~11	11~12	12~13	
Copepoda																
Acartia spinicauda	1											CC 1				>9.316
A. iseana	6							+ 2	+ 1	R 1		CC 1			+ 1	5.560~12.928
A. tsuensis	12								C 1	CC 10	C 1					6.696~ 8.968
Oithona nana	6								R 2	R 2			R 1		R 1	6.448~12.928
Sinocalanus tenellus	115	R 3	+ 9	C 33	CC 19	C 15	C 6	+ 4	+ 10	C 7	C 5	CC 1	R 1		CC 1	0.240~12.928
Pseudodiaptomus inopinus	155	R 3	+ 15	C 57	C 33	CC 16	CC 8	C 6	CC 7	C 9						0.240~ 7.952
Eodiaptomus japonicus	5					RR 3	RR 2									<4.648
Paracyclopina nana	28			RR 1	R 1	+ 11	+ 5	+ 3	+ 3	C 4						1.680~ 7.596
Mesocyclops leuckarti	22	+ 2	+ 7	C 9	R 2											0.240~ 2.688
Thermocyclops taihokuensis	2	+ 1	R 1													0.412~ 0.752
Cyclops vic nus	1			RR 1												<1.296
Cladocera																
Moina dubia	50	CC 1	C 11	C 30	+ 5	RR 2										0.412~ 3.496
Alona rectangula	2	+ 1		RR 1												0.232~ 1.112
Bosmina longirostris	5					RR 4	RR 1	RR 1								<4.648
Mysidacea																
Neomysis japonica	42			+ 8	CC 7	CC 5	C 3	C 2	+ 3	C 12	RR 2					1.256~ 8.528
Larva																
Balanus nauplius larva	38		RR 2	R 7	R 12	R 5	R 6	R 1	R 4	+ 1						0.872~ 7.912

Table 4. Occurrence of plankton rotifers and protozoon in eel-culture ponds of varying salin
The figure indicates the number of ponds, in which the species was foun
ccc, very abundant; cc, abundant; c, frequent; +, common; r, rate; rr, very

Species	Col-lected ponds	Chlorine contents of the pond water Cl ‰										
		0.1 ~ 0.5	0.5 ~ 1.0	1 ~ 2	2 ~ 3	3 ~ 4	4 ~ 5	5 ~ 6	6 ~ 7	7 ~ 8	8 ~ 9	9 ~ 10
Rotifera												
Brachionus calyciflorus	98	CC 3	CC 16	CC 49	CC 22	C 6	R 2					
Br. quadridentatus	55		+ 5	R 31	R 12	R 3	R 2	RR 1				
Br. angularis	50	R 2	+ 7	+ 28	+ 10	C 5	R 2					
Br. urceolaris	90	RR 1	R 9	R 37	+ 22	C 11	R 6	R 2	RR 1			
Br. plicatilis	47		C 2	CC 9	CC 7	CCC 11	CCC 4	CCC 7	CCC 3	CCC 3		
Keratella cruciformis eichwaldi	12		R 2	+ 5	+ 2	R 1	R 1	R 1				
K. cochlearis	6					RR 3	RR 3					
K. valga	43	C 1	+ 10	+ 25	R 6							
K. quadrata	2					RR 2						
Filinia longiseta	17	+ 1	+ 9	R 8								
Polyarthra trigla	13	RR 1	+ 1	R 11								
Asplanchna sp.	10		R 2	R 6				RR 1				
Asplanchnopus syrinx	10			+ 10								
Testudinella clypeata	8					RR 4	RR 4					
Pedalia fennica	19		R 1	+ 6	+ 1	+ 2	+ 2	+ 4	+ 1	+ 2		
Lecane sp.	6			RR 2	RR 3				RR 1			
Monostyla sp.	3		RR 1	RR 1			RR 1					
Protozoa												
Ceratium macroceros	2							C 1	R 1			
C. furca	2							R 1	R 1			
C. hirundinella	2					RR 1	RR 1					
Favella ehrenbergi	2							C 1	+ 1			
Tintinnopsis radix	1							R 1				

Table 3. Occurrence of plankton crustaceans in eel-culture ponds of varying salinities, Mie Prefecture.
The figure in the table shows the number of ponds.

ある。棲息塩分範囲は Cl 0.240～12.928‰ である。SMIRNOV (1932) は本種について，日本産と沿海州産は異るとして，それぞれ亜種，*S. tenellus insulanus*, *S. tenellus continentalis* として区別した。しかし多くの材料について精査したところ，両亜種を明瞭に識別することは困難のようである。その詳細については別に報告する予定である。なお従来本邦各地の汽水湖から報告された *Limnocalanus sinensis* は *Sinocalanus tenellus* とすべきものである。

Pseudodiaptomus inopinus は *Sinocalanus tenellus* と同様に典型的な汽水産橈脚類で，前種と相伴つて本邦各地の汽水湖に広く分布する。三重県養鰻池においても極めて普通に分布し，量的にも重要なプランクトン動物で，棲息塩分範囲は Cl 0.240～7.952‰ である。*Pseudodiaptomus japonicus* KIKUCHI は MASHIKO and INOUE (1952) が既に指摘しているように *P. inopinus* BURCKHARDT のシノニムとすべきものであろう。

Acartia iseana 並に *A. tsuensis* は海産由来のものであることは明かで，♀ ♂ の第5脚の形態その他の標徴が既知の *Acartia* 属の種と著しく異る。*iseana* と *tsuensis* との相異点は ITO (1956) に掲げた。両種はヨーロッパの汽水域に広く分布する *Acartia discaudata* と同様に汽水に適応した汽水性種に属するものと思われる。*iseana* は阿漕，香良州，天白・松ヶ崎，松阪地区の天然汽水性養魚池にのみ見出された。その棲息塩分範囲は Cl 5.560～12.928‰ である。*tsuensis* は上野，部田，津，雲出地区の養殖休止中の養鰻池並に天然養魚池に夥しく繁殖していた。その分布範囲は Cl 6.696～8.968‰ であつた。両種は同時に採集されることはなかつた。

Paracyclopina nana は最初 SMIRNOV (1932) が沿海州のスイフン河口から1新属1新種として記載したもので，本邦では小久保・佐藤 (1947) は十三潟 (Cl 7.01～15.44‰ の水域)，益子 (1949, 1950, 1951, 1952) は河北潟，舳倉島竜神池 (Cl 5.730‰)，邑知潟 (Cl 0.227～0.504‰)，北潟 (1.40～2.23‰) から報告した。現在までの分布は日本海沿岸に限られていたが，今回の調査によつて，伊勢湾西岸の汽水性養魚池に広く分布することが分つた。即ち伊曽島から松阪に亘り，広く分布し，天然汽水池，休止中の養鰻池は勿論，養殖中の養鰻池にも見出された。その棲息塩分範囲は Cl 1.680～7.596‰ で可成広く，季節的には殆んど周年見られるが，4～11 月に多い。水変り時に *Brachionus plicatilis* の大集団と共存し，生活力は強い（伊藤 1955)。量的には *Sinocalanus*, *Pseudodiaptomus* に比べると重要ではない。

Brachionus plicatilis は本邦では汽水域のみに分布する純汽水性輪虫類で，本邦汽水湖からは羽田 (1939) により春採湖，湖山池 (Cl 1.10～2.76‰) から，益子 (1950) は舳倉島無名小池 (Cl 3.30‰) から報告したのを知るのみであるが，他の汽水湖から発見される可能性が大きい。三重県の汽水性養魚池には橈脚類の *Sinocalanus*, *Pseudodiaptomus* と同様に夥しく増殖し，その棲息塩分範囲は極めて広く，Cl 0.664～7.248‰ に亘つている。特にこの動物の重要性は，他の大部分の輪虫類は Cl 5‰ 以上の池には殆んど出現しないのに拘らず，それ以上の高鹹水域に分布している点であり，地域的には北は伊曽島から南は志摩地方の穴川に亘り広く分布する，且つ Cl 3‰ 以上の高鹹な養鰻池における水変りには殆んど例外なく本種の異常増殖が伴い，Cl 3‰ 以下の池の水変りには淡水系の *Brachionus calyciflorus* の大増殖の伴うことと著しい対照をなしている。本種は温水性に属し，季節的には 5～6 月から大増殖をはじめ，それは 10 月まで継続し，

11 月から消滅し，その他の冷水期には見出されない。増殖期は水温 20°C 前後以上である。

Pedalia fennica は本邦においては益子 (1951) により日本海の舳倉島竜神池 (Cl 5.730‰) から最初に報告された。伊勢湾西岸の養鰻池においては，川越，江戸橋，部田，津，香良州地区から見出された。その棲息塩分範囲は Cl 0.892～7.144‰ に亘つている。しかし量的には重要ではない。温水性種に属し，夏季を中心とする暖期に見られ，特に水変り時に *Br. plicatilis* に相伴つて出現することが多い。(伊藤，1955)。

Keratella cruciformis var. *eichwaldi* は純汽水性輪虫類の 1 種であり，本邦汽水湖においては最初に羽田 (1938) が春採湖 (北海道，Cl 1～3‰) から，次いで羽田 (1939) は温根沼 (北海道，Cl 1.0～7.2‰)から報告した。其の後，益子 (1949) は河北潟 (Cl 3～4‰) から，山元 (1952) は同じく河北潟から報告したのを知るのみである。伊勢湾西岸の養鰻池では，伊曽島，川越，楠，江戸橋，松阪地区の 12 面の養鰻池に見出された。棲息塩分範囲は現在までの調査では，Cl 0.872～5.512‰ である。養鰻池では *Br. plicatilis* の大増殖の先駆として 5～6 月上旬に大発生をする場合がある。

Testudinella clypeata は伊勢湾西岸養鰻池では Cl 3.232～4.796‰ の汽水域から採集され，現在までに部田地区のみで見られ，殆んど周年出現するが，量的には重要でない。

Balanus nauplius larva は伊曽島，川越，楠，白子・磯山，上野，江戸橋地区の Cl 0.872～7.912‰ の汽水性養魚池のプランクトン中に広く出現した。量的には多くないが，成体は池中の杭に附着している。種名は明かにしていない。

Neomysis japonica (ニホンアミ) は大型のプランクトンに属し，“コマセ”と俗称している。*Sinocalanus*，*Pseudodiaptomus* 等の橈脚類に次いで伊勢湾西岸の汽水性養魚池に広く分布する。その棲息塩分範囲は Cl 1.256～8.528‰ で広い。養殖中の養鰻池のみでなく，休止中の池並に天然池にも出現し，夥しい個体数に達する場合がある。水変りによる酸素欠乏に弱く，大きい水変りには絶滅する。水変りに対する指標動物として橈脚類の *Sinocalanus*，*Pseudodiaptomus* と共に重要である。

c) **淡水系**—本来淡水産であるが，塩分に対する適応性がく，汽水域にまで侵入しているもので現在までに次の 19 種が見出された。

橈脚類: *Eodiaptomus japonicus*, *Mesocyclops leuckarti*, *Thermocyclops taihokuensis*, *Cyclops vicinus*.

枝角類: *Moina dubia*, *Alona rectangula*, *Bosmina longirostris*.

輪虫類: *Brachionus calyciflorus*, *Br. quadridentatus*, *Br. angularis*, *Br. urceolaris*, *Keratella cochlearis*, *K. valga*, *K. quadrata*, *Filinia longiseta*, *Polyarthra trigla*, *Asplanchna* sp., *Asplanchnopus syrinx*.

原虫類: *Ceratium hirundinella*.

種類相は海産系，汽水系に比して最も卓越している。

Eodiaptomus japonicus は Burckhardt (1913) に依り琵琶湖から最初に記載され，その後関東，近畿，中国，四国の平地の小池に分布することが分つた。(Kikuchi, 1928, 1936)。本邦汽水湖においては菊池 (1936) は三方湖，菅湖，水月湖から，益子・野崎・井下 (1951) は知潟 (Cl 0.2～0.5‰) から報告している。伊勢湾西岸養鰻池においては，部田地区に僅かに見出され，その分布範囲は Cl 4.648‰ 以下で，量的には極めて少い。

Mesocyclops leuckarti の分布は普遍的であり，本邦淡水湖に最も普通に見られる。汽水湖においては小久保・佐藤 (1947) は十三潟附属の明神沼 (Cl 0.11‰) から，元田 (1950) は石狩古川 (河跡湖，Cl 0.20～0.976‰) から，益子・野崎・井下 (1951) は邑知潟 (Cl 0.2～0.5‰) から，MASHIKO and INOUE (1952) は紫山潟 (Cl 0.05～0.279‰) 並に今江潟 (Cl 1.532～4.540‰) から報告している。伊勢湾西岸養鰻池では川越，白子・磯山，雲出，香良州，松阪地区に亘り，22 面の養鰻池に見出された。その分布範囲は Cl 0.240～2.688‰ であった。高安・左十鼠・近藤 (1934 b) は温根沼 (北海道，Cl 10～17‰) に本種の出現を報告しているが疑はしい。

Table 5. Geographical distribution of plankton crustaceans in eel-culture ponds on the west coast of Ise Bay, Mie Prefecture.
The figure in the table shows the number of ponds, in which the species distributed.

Region / Ponds	Isoshima	Jōnan	Kawagoe	Kusu	Shiroko・Isoyama	Ueno	Edobashi	Heta	tsu	Akogi	Kumozu	Karasu	Matsugasaki・Tenpaku	Matsusaka	Anagawa
Species	5	20	46	24	17	18	17	21	9	10	11	8	9	14	10
Copepoda															
Acartia spinicauda										CC 1					
A. iseana										C 3		C 1	+ 1	R 1	
A. tsuensis						C 1		CC 7	+ 2		CC 3				
Oithona nana													R 2	R 2	R 2
Sinocalanus tenellus	R 2	C 11	+ 19	C 4	C 14	+ 2	CC 7	CC 8	C 5	C 6	C 5	+ 2	CC 9	C 12	C 9
Pseudodiaptomus inopinus	R 2	R 7	C 40	C 22	C 15	C 11	CC 15	CC 7	CC 4	CC 5	CC 5	+ 6	+ 3	C 10	+ 3
Eodiaptomus japonicus								RR 5							
Paracyclopina nana	R 1				RR 1	+ 4	+ 10	+ 4	C 4		+ 2			+ 2	
Mesocyclops leuckarti			+ 12		+ 1						+ 1	C 1		C 7	
Thermocyclops taihokuensis			R 2												
Cyclops vicinus			RR 1												
Cladocera															
Moina dubia		+ 4	C 21	RR 1	R 1	+ 2	C 4	+ 2		CC 1	C 2	CC 5	R 1	C 6	
Alona rectangula			RR 1		+ 1										
Bosmina longirostris								RR 5							
Mysidacea															
Neomysis japonica		C 3		C 3	C 3	CC 27	R 2	C 13	C 2	CC 4	+ 1				+ 4
Larva															
Balanus nauplius larva	R 1		R 15	R 7	R 6	R 4	R 3						+ 1	R 2	

Thermocyclops taihokuensis は HARADA (1937) により台湾の台北附近から記載されたものであるが，その後菊池 (1942) は満洲にも広く分布することを報告した。朝鮮並に本邦各地の池沼にも広く分布するが，現在までにその分布状況は明かでない。本邦汽水

Table 6. Geographical distribution of plankton rotifers and protozoon in eel-culture ponds on the west coast of Ise Bay, Mie Prefecture.
The figure in the tale show the number of ponds, in which the species distributes.

Region / Ponds / Species	Isoshima	Jōnan	Kawagoe	Kusu	Shiroko・Isoyama	Ueno	Edobashi	Heta	Tsu	Akogi	Kumozu	Karasu	Matsugasaki・Tenpaku	Matsusaka	Anagawa
	5	20	46	24	17	18	17	21	9	10	11	8	9	14	10
Rotifera															
Brachionus calyciflorus	C 2	CC 16	CC 44	C 3	CC 5	CC 4		C 3	CC 1	CC 1	CC 3	CC 6	CC 1	CC 9	
Br. quadridentatus	RR 2	R 10	R 12	R 9	RR 1	+ 6		RR 2		C 1	+ 1	+ 3		R 4	
Br. angularis	C 3	R 10	R 12	C 6	R 4	R 3	+ 1	+ 2				C 4	R 2	+ 7	
Br. urceolaris	+ 3	R 12	+ 17	+ 20	+ 5	R 8	C 5	+ 3		CC 1	+ 6	+ 4	+ 2	+ 4	
Br. plicatilis	C 3	RR 2	R 4			CC 1	CCC 12	CC 4	CCC 7		CC 4	CC 4		+ 4	+ 1
Keratella cruciformis eichwaldi	+ 1		+ 7	R 1			R 1							R 2	
K. cochlearis								RR 6							
K. valga		R 5	+ 34											+ 4	
K. quadrata								RR 2							
Filinia longiseta		RR 1	R 13			+ 1						+ 2			
Polyarthra trigla		RR 3	R 6		+ 1							+ 1		+ 2	
Asplanchna sp.	RR 1	R 2	R 5		RR 1	+ 1									
Asplanchnopus syrinx		R	R 6									C 3			
Testudinella clypeata								RR 8							
Pedalia fennica			R 2				+ 5	+ 3	+ 5			+ 4			
Lecane sp.	R 1		R 4										R 1		
Monostyla sp.			R 1									RR 1		RR 1	
Protozoa															
Ceratium macroceros					R 1							C 1			
C. furca					R 1							R 1			
C. hirundinella								RR 2							
Favella ehrenbergi					+ 1							C 1			
Tintinnopsis radix												R 1			

湖においては益子・野崎・井下 (1951) は邑知潟 (Cl 0.2～0.5‰), Mashiko and Inoue (1952) は今江潟 (Cl 1.5～45‰), 柴山潟 (Cl 0.05～0.279‰), 木場潟 (Cl 0.06～0.271‰) から報告している。本調査結果によると三重県養鰻池においては, 川越地区の 2 池に僅かに見出された。其の塩分範囲は Cl 0.412～0.752‰ で, 量的には *Mesocyclops leuckarti* に比べると少い。

Cyclops vicinus は川越地区の 1 池 (Cl 1.296‰) にのみ僅かに見出された。稲葉 (1934) は静岡県吉田地方の養鰻池から本種の出現を報じた。

Moida dubia は熱帯性枝角類に属し (上野, 1937 b, p. 70～71), 本邦からは益子・野崎・井下 (1951) により最初に邑知潟 (Cl 0.2～0.5‰) から報告された。伊勢湾西岸の養鰻池においては, 城南から松阪に亘り広く分布し, 50 個の池から採集された。量的には極めて多く, *Sinocalanus*, *Pseudodiaptomus* 等の橈脚類と共に重要なプランクトンの 1 つである。其の分布塩分範囲は Cl 0.412～3.496‰ であるが, 塩分の大きい池程, その生産は少く, Cl 2‰ 以上の水域には少い。

Alona rectangula は本邦汽水湖においては, 高安・五十嵐・近藤 (1934 b) により湧洞沼 (北海道, Cl 0.875～1.850‰) から, 益子・野崎・井下 (1951) は邑知潟 (Cl 0.2～0.5‰) から, 小久保・佐藤 (1947) は明神沼 (Cl 0.11‰) から報告している。また稲葉 (1934) は静岡県吉田地方の養鰻池から見出している。三重県養鰻池における本種の出現は稀であり, 川越並に白子・磯山地区の 2 池から採集された。その出現塩分は Cl 1.112‰ 以下である。

Bosmina longirostris の本邦汽水湖への出現は, 湧洞沼 (Cl 0.875～1.850‰, 高安・五十嵐・近藤, 1934 b), 邑知潟 (Cl 0.2～0.5‰, 益子・野崎・井下, 1951), 網走湖 (Cl 0.33～0.68‰, 元田, 1950), から報告されている。三重県養鰻池においては, 部田地区のみから僅かに見出され, 個体数は少く, その出現塩分は Cl 4.648‰ 以下である。

Brachionus calyciflorus は伊勢湾西岸養鰻池に最も広く, 且つ多量に出現する輪虫類であり, 239 面の調査池中で 98 面の池に見出された。地域的には穴川を除いた全地域に広く分布する。その分布塩分範囲は Cl 0.232—4.568‰ で, Cl 5‰ 以上の水域からは全く見出すことは出来なかつた。量的に多いのは Cl 3‰ 以下であり, Cl 4～5‰ 水域の分布と生産は少く, Cl 3‰ 以上の汽水域では汽水性の *Br. plicatilis* と交替することは前述した通りである。本種は Cl 3‰ 以下の低鹹な養鰻池の水変り時に大増殖を示す。稲葉 (1937) は静岡県浜名地方の水変り時には本種の大増殖の伴うことを報告し, 且つ本種の海水に対する抵抗試験の結果 Cl 5‰ 以上では全く斃死することを見ている。この致死塩分濃度は自然の養鰻池における本種の分布界限と略々一致している。三重県の養鰻 池に出現する *Br. calyciflorus* の型は限られており, forma *amphiceros*, s. str., forma *anuraeiformis* の 3 型である。全体的に見ると, f. *amphiceros* の分布範囲は Cl 0.232～1.276‰ で他の 2 型に比して低鹹水域に出現し, 一方 s. str., と f. *anuraeiformis* は殆んど相伴つて出現し, その分布範囲は Cl 0.664～4.568‰ で高鹹水域に亘つていた。Kikuchi (1931) によると, 本種は *Polytoma* (Protozoa, Flagellata, Chlamydomonadidae) で飼育すると後方棘のない型を生じ, *Scenedesmus* (Chlorophyceae) を餌料とすると, 後方棘を有する型を生じ, 水温, 塩分, pH 等は直接外形の変異に影響せず, 餌料の質的変化がこの変異をおこす原因であるという。若しそうならば, 上述の池水の塩分含有

量の相異による型の変化は，塩分含有量によるプランクトン植物相の相異に起因していると考えるべきものであろう。

Brachionus quadridentatus の養鰻池への出現は *Br. calyciflorus* 程量的には多くない。しかし伊勢湾西岸の全域に亘つて養鰻池に広く分布している。その分布範囲は Cl 0.704～5.736‰ であるが，Cl 5‰ 以上の水域への出現は極めて稀である。これらの養鰻池に出現するのは，var. *brevispinus* (Cl 0.876～1.784‰), var *entzii* (Cl 1.136～1.296‰), var. *rhenanus* (Cl 0.876～3.432‰), var. *cluniorbicularis* (Cl 3.268‰) の 4 型である。全体的に見ると，池水の塩分濃度が大きい程側後棘の発達は悪くなり，*brevispinus* → *entzii* → *rhenanus* → *cluniorbicularis* の系列になる傾向がある。これは *Br. calyciflorus* のそれと並行的である。

Brachionus angularis も三重県養鰻池に広く分布する。しかし量的には多くない。その分布範囲は Cl 0.232～4.594‰ で Cl 5‰ 以上の汽水域には出現しない。被甲の角ばつた *angularis* と，円い var. *bidens* の 2 型が見られた。本邦汽水湖では，*angularis* は，春採湖，湖山池，宍道湖（羽田，1939，Cl 2.76‰ 以下），石狩古川（元田，1950，Cl 0.20～0.976‰），今江潟（Mashiko and Inoue，1952，Cl 1.5～4.5‰），北潟（Mashiko and Inoue, 1952, Cl 1.4～2.0‰）から報告され，var. *bidens* は邑知潟（益子・野崎・井下，1951，Cl 0.2～0.5‰）のみから報告されているに過ぎない。

Brachionus urceolaris は陸水においてはアルカリ性水域に出現するが，（Ahlstrom, 1940），酸性水域（一髪内湖，pH＝2.8，上野，1934；恐山湖，pH＝3.1～3.4，小久保・田村・阿部，1931）にも分布し，適応性の強い輪虫類である。本邦汽水湖では，八郎潟（秋田水試，1936，Cl 1.0～5.28‰；小久保，1944，Cl 2.03～6.36‰），水月湖（小久保，1944，Cl 4.40‰）から報告されている。本調査の結果によると，三重県養鰻池では 239 面の池中 90 池から見出され，津・阿漕・穴川の 3 地区を除いた全域に広く分布し，その分布塩分範囲は，Cl 0.456～6.992‰ に亘つているが，Cl 5‰ 以上の水域への出現は量的には少い。稲葉（1934，1936），稲葉（1937）によると静岡県養鰻池においては水変り時に *Br. calyciflorus* と共に大発生することを見ているが，三重県養鰻池においては本種は量的には *Br. calyciflorus* 並に *Br. plicatilis* に比べると余り重要ではない。稲葉（1937）は *Br. calyciflorus* と *Br. urceolaris* の塩分に対する致死限界は Cl 5‰ 以上であることを見ているが，この致死濃度は天然の養鰻池における *Br. urceolaris* の分布限界と略し一致している。

Keratella valga は三重県養鰻池においては，城南，川越，松阪の 3 地区のみから見出され，特に川越地区では卓越し，46 池中 34 池から採集された。その分布塩分範囲は Cl 0.412～2.688‰ であるが，Cl 2‰ 以上の水域への出現は少い。全体として量的には重要でない。本邦汽水湖では八郎潟（秋田水試，1936，Cl 1～5.2‰），涸沼（小久保，1944，Cl 3.47‰），河北潟（益子，1949，Cl 3～4‰），木場潟（Mashiko and Inoue，1952，Cl 0.06～0.271‰）から報告され，*K. valga* f. *tropica* は北潟（Mashiko and Inoue, 1952），*K. valga* f. *monstrosa* 並に *f. asymmetrica* は夫々邑知潟（益子・野崎・井下，1951，Cl 0.2～0.5‰）から報告されている。

Filinia longiseta は本邦汽水湖では八郎潟（小久保，1944，Cl 203～6.36‰），石狩古川（元田，1950，Cl 0.20～0.976‰），春採湖（羽田，1938，Cl 1～3‰），邑知潟（益子・野崎

・井下，1951，Cl 0.2～0.5‰)，北潟 (MASHIKO and INOUE, 1952, Cl 1.4～2.0‰) から報告されている。本調査の結果によると，三重県養鰻池では，城南，川越，上野，香良洲地区の 17 池から採集され，その分布塩分範囲は Cl 0.656～1.219‰ であつた。量的には多くない。

Polyarthra trigla は三重県養鰻池では，城南，川越，白子・磯山，香良洲，松阪地区の 13 箇所の池から採集され，その棲息塩分は Cl 0.440～1.648‰ で，1‰ 以上の水域への出現も稀ではない。全体的にはその量は重要でない。本邦汽水湖では，春採湖（羽田，1938，Cl 1～3‰），石狩古川（元田，1950，Cl 0.20～0.976‰），網走湖（元田，1950，Cl 0.33～0.68‰），邑知潟（篠・野崎・井下，1951，Cl 0.2～0.5‰）から見出され，本種の汽水域への侵入は Cl 1‰ 以下のようである。

以上の伊勢湾西岸における 239 箇所の汽水性養魚池のプランクトン動物相は次のように要約出来るであろう。第 1 に上述の養鰻池を主とする汽水性養魚池の動物性プランクトンは，本邦の他の天然汽水湖と共通種から成り，養鰻池特有の種類は見られない。しかし *Acartia iseana* ITO，並に *A. tsuensis* ITO の 2 種の橈脚類が休止中の養鰻池並に天然池に多数見出されたことは注目すべきものであろう。第 2 に三重県の養鰻池のプランクトン動物で卓越しているのは汽水種であり，*Sinocalanus tenellus*, *Pseudodiaptomus inopinus*, *Neomysis japonica*, *Brachionus plicatilis* 等がその分布も広く量的にも多い。一方塩分濃度の少ない養鰻池には淡水産の *Moina dubia*, *Brachionus calyciflorus*, *Br. quadridentatus*, *Br. angularis*, *Br. urceolaris*, *Keratella valga* 等が卓越している。両者に対して海産系の侵入は極めて少い。養鰻池は一般に過栄養型であり，植物性プランクトンの生産は勿論，動物性プランクトンの生産量も大きく，特に輪虫類の生産が卓越しているのは特筆すべきであろう。

2. 主要種の地理的分布

伊勢湾西岸の汽水性養魚池における動物性プランクトンの地理的分布は Tables 5～6 に示した。主要種についてその地域的分布を見ると，プランクトン甲殻類では典型的汽水性橈脚類の *Sinocalanus tenellus*, *Pseudodiaptomus inopinus* は例外なく北は伊曽島から南は志摩地方の穴川に亘り全地域に分布し，*Moina dubia*, *Neomysis japonica* も殆んど全地域に分布している。輪虫類では，低鹹養鰻池の水変りに大増殖をする淡水産の *Brachionus calyciflorus* は穴川地区には全く見られず，江戸橋地区には極めて少く，その他の地域に広く分布する。一方高鹹養鰻池の水変りに大発生する *Br. plicatilis* は上野，江戸橋，栗真，津，藤方，香良洲の中勢地方に著しくよく繁殖し，楠，白子・磯山，天白・松ヶ崎地区の池には全く見られず，また城南，川越，並に松阪地区には少い。*Br. quadridentatus*, *Br. angularis*, *Br. urceolaris* 等は穴川を除く全地域に分布している。

3. 種　　数

上述の伊勢湾西岸の 239 の汽水性養魚池の各々についてその動物性プランクトンを構成している種の数と池水の塩素含有量との関係を総括すると Table 7 になる。最大は 10 種，最小は 1 種で，2, 3, 4 種によつて構成されている場合が最も多く全体の 57% を占めている。それらの構成主要種は，*Sinocalanus tenellus*, *Pseudodiaptomus inopinus*, *Neomysis japonica*, *Brachionus plicatilis* の汽水系，並に *Br. calyciflorus*, *Br.*

quadridentatus, *Br. urceolaris* 等の淡水系で，これらの主要種の 2, 3, 或いは 4 種の組合はせから成つているのが普通である。次にこれらの種数と池水の塩分との関係は，Table 7 に明かのように，池水の塩分含有量が大きくなる程プランクトンを構成している

Table 7. The relation between the number of species of plankton animals and the salinity of the pond water, Mie Prefecture.
The figure in the table shows the number of ponds.

Species \ Salinity	Chlorine contents of the pond water Cl ‰												Total	
	0.1～1.0	1～2	2～3	3～4	4～5	5～6	6～7	7～8	8～9	9～10	11～12	12～13	Number	%
Number of Species 10	1	4											5	2.0
9	1	5	1										7	2.9
8	4	4	1	1	1								11	4.6
7	4	9	5	1	1								20	8.4
6	3	6	2	3	2	2	2	2					22	9.2
5	4	8	3	5	1	2	1	1					25	10.4
4	3	14	13	5	2	3	1	1	1				43	17.9
3	3	19	11	6	2	1	3	3	1	1		1	51	21.3
2	2	8	8	4	2	1	6	9	2		1		43	17.9
1		6	1	1		1	1	3	3				12	5.0
Total	25	79	45	26	11	10	14	19	7	1	1	1	239	100

種数は減少する傾向があり，プランクトン動物相は単純になる。上野 (1951) によると淡水湖の代表である青木湖のプランクトン動物は略々一定し，20種から成つているという。本学水産学部浮游生物学教室赤塚孝三氏によると，伊勢湾のプランクトン動物は 5 月～11 月には，常時約 37 種出現するという。これらに比べると伊勢湾西岸の汽水性養魚池の動物性プランクトンは 1～10 種か成り，特に大部分が 2～4 種から成ることから見ると，汽水性養魚池のプランクトン動物相は極めて貧弱であり単純であるといえよう。これはこれらの養鰻池が強い非調和性の陸水学的性格をもつている 1 つの証左と考えるべきものであろう。

4. 水変り池のプランクトン動物相

今回調査した 239 面の汽水性養魚池の中，Table 8 に示した 9 面の養鰻池が水変り中か又は水変り後の時期にあつた。Nos. 200, 613, 618, 703, 1011 池はいずれも軽度の水変り中でウナギの摂餌は全くない状態であり，No. 200 池ではウナギは水車附近に集合していた。No. 408 池は水変り中で，ボラが斃死し，池水は硫化水素の臭気を発していた。

Nos. 01, 04, 003 池の 3 池は水変りの後にあたり，01 池は 9 月下旬に水変りがあり，ボラは全滅し，ウナギ約 5 貫が斃死した。調査時には池水は透明で池底まで透視され，餌付は稍々良くなり，水変りは回復期にあつた。04 池も 9 月下旬に水変りがはじまり，池水は著しく澄み，ハゼ類が斃死した。調査時には餌付は全くなかつた。003 池も 9 月下旬から水変りになり，調査時には稍々回復し，餌付は稍々不良程度であつた。上述の 9

Table 8. Plankton fauna of "Mizukawari" eel-culture ponds in Mie Prefecture.

*) *Branchionus plicatilis* in the table 2 of the preceding paper (ITO,, 1955b, p. 174) is a misprint.

Pond number	Region	Date	W. T.	Dissolve doxyden		pH	Cl ‰	Water colour	Dominant plankters
				cc/l	%				
208	Kumozu	Sep. 9. '53	22.9	3.29	53.2	7.3	3.268	Yellowish Brown	*Brachionus calyciflorus**) cccc, *Pseudodiaptomus inopinus* cc
408	Tsu	Aug. 19. '53	25.8	1.58	27.4	7.7	5.828	Brown	*Br. plicatilis* ccc *Br. urceolaris* cc, phytoplankton ±
613	Edobashi	Aug. 31. '54	27.8	3.70	66.0	7.3	4.592	〃	*Br. plicatilis* ccc
616	〃	〃	28.5	4.00	73.3	7.2	1.896	Yellowish Brown	*Br. plicatilis* ccc, *Pseudodia. inopinus* cc
703	Shiroko	Oct. 12. '54	18.3	4.20	62.5	6.9	0.440	Milky Green	*Br. calyciflorus* ccc, *Microcystis* ±
1011	Kawagoe	Oct. 19. '54	19.0	4.20	64.6	7.1	1.096	Brown	*Br. calyciflorus* ccc, *Microcystis* ±
01	Matsugasaki	Oct. 21. '54	19.3	2.80	43.1	6.9	2.192	Clear	*Sinocalanus tenellus* ccc
04	〃	〃	19.2	2.20	34.5	6.9	1.024	Milky Green	*S. tenellus* ccc
003	〃	Oct. 22. '54	18.6	3.30	49.4	7.1	2.752	Milky Brown	*S. tenellus* ccc *P. inopinus* ccc

面の水変り養鰻池においては池水の pH は低く (6.9～7.3), 溶存酸素量は少く (1.58～4.20CC/L, 27～73%), 植物性プランクトンは著しく減少するか, 或いは殆んど消滅し, それに伴つて透明度は著しく大きくなり, 池水の水色も緑色から暗褐色, 乳褐色或は無色に変化している。

これらの水変り養鰻池のプランクトン動物相の特徴としては, Table 8 に明かのように, Nos. 200, 703, 並に 1011 池の水変りには淡水産輪虫類の *Brachionus calyciflorus* の大増殖が見られ, Nos. 408, 613, 並に 616 池では汽水産輪虫類の *Brachionus plicatilis* の大増殖が見られている。しかし Nos. 01, 04, 並に 003 池では, 調査時には輪虫類の大増殖は見出されず, 汽水性橈脚類の *Sinocalanus tenellus*, *Pseudodiaptomus inopinus* が大増殖していた。これらの水変り池に果して輪虫類が大増殖をしなかそたかということについてはその水変りの経過の観測資料を欠いでいるので不明である。唯々本調査が水変り後 2～3 週間を経過しているので, 輪虫類の増殖, 消滅は更に短期間であるので, 調査時には輪虫類が消滅し水変りは回復期にあり, 前記の橈脚類の増殖期に当つていたのではないかと思われる。

これらの水変り養鰻池における輪虫類の大増殖は稲葉 (1934, 1936) の静岡県吉田地方, 稲葉 (1937) の浜名地方における報告とよく一致している。しかし静岡県の池では *Brachionus calyciflorus*, *Br. urceolaris* であるが, 三重県の養鰻池では, Cl 2～7‰ の高鹹な養鰻池では汽水性輪虫類の *Br. plicatilis* の大増殖が見られるのに対し, Cl 0.2～3‰ の低鹹養鰻池では淡水産輪虫類の *Br. calyciflorus* の大増殖が見られる点は静岡県の水変りのそれと異つている。これは前述したように静岡県養鰻池の池水の塩分が三重県のそれに比して低鹹であることの生態環境の差に原因していると考えられる。

V. 考　　察

1. 伊勢湾西岸における汽水性養魚池のプランクトン動物相—塩分関係による分類

汽水湖の分類に関し, Redeke (1922, 1936) は "汽水はそれ自身唯一つの生態区をなすのではなくて, その中を更に生態的に際立つたいくつかの汽水域に区分することが出来る。各汽水域は特異な環境要因とそれに応じた特有の生物社会を持つている" ことを強調し, オランダの汽水をその塩素含有量と動物の分布から次のように分類した。

汽水の分類 (Redeke, 1936)

Cl ‰		
<0.1	Fresh-water	
0.1～ 1.0	Oligohaline	
1.0～ 5.5	α-Mesohaline	Brackish-water
5.5～10.0	β-Mesohaline	Brackish-water
10.0～17.0	Polyhaline	
>17.0	Sea-water	

この分類方式は Gessner (1937) によつてその妥当性が支持された。本邦汽水湖のプランクトン相による類型化に関しては小久保・佐藤 (1947) が純汽水性プランクトンの

Sinocalanus, *Pseudodiaptomus* の棲息域，塩分の点からは，Cl 2～7‰ を“汽水域”と規定することを提案している。

プランクトン・塩分関係による汽水湖の類型化には多くの困難性がある。第 1 に湖水の塩素含有量は海水並に淡水の注入に支配され，水平的差異が大きく，また同一地点においても時間的，季節的変化が大きい。第 2 に一般に塩分の垂直的成層が顕著で，底層は海水に近いのに，表層水は淡水に近い場合もある。第 3 に塩素含有量のみがプランクトンの分布を支配する要因ではなくて，他に物理化学的，地理的，時間的，或いはそれらの結合された要因の外に生物学的要因も無視することは出来ない。第 4 にプランクトンはベントスに比べて分布の安定性に乏しく，水の流動，風その他の影響で分布が撹乱され，偶然性の介在の危険性がある。第 5 に塩分分布の不均等な湖水においてはプランクトン・サンプリングが水質要素程に精細に従来行はれていない。このような理由で天然の大きい汽水湖においてプランクトンの分布と塩分との関係をはつきり見定め，分布境界を設定し，多くの汽水湖をこの関係から類型化することには大きい困難が横はつている。

しかし伊勢湾西岸の海岸線に膚接し存在する汽水性養魚池群においては，いづれも小さく且つ浅く（約 1～2 m），しかも天然湖に比して各池は海水並に淡水から粗ではあるが隔離され，いろいろの塩分濃度の池が極めて多数に存在し，それらのプランクトン動物相は全体的には本邦の天然汽水湖のそれと略々同じであるから，養魚池というい く分人工的影響もあるが，プランクトンの分布と塩分との関係を見定めるには好適の場であるといえよう。このような見地から，前述した伊勢湾西岸にある 239 面の汽水性養魚池におけるプランクトン動物の分布と池水の塩分との関係を考察して見る。Figs. 3～4 を注意深く検討すると，全体的には塩素含有量 0.2，1，5，8～10‰ の 4 カ所にプランクトン動物の分布の限界があるように思はれる。

a）分布限界 Cl 0.2‰（汽水の下限）

典型的な汽水性プランクトンの *Sinocalanus tenellus* (Kikuchi), *Pseudodiaptomus inopinus* Burckhardt はすでに Cl 0.240‰ から出現している。それ以下の水域は本調査では見られなかつたが，小久保・佐藤（1947）によると十三潟附属の明神沼（Cl 0.11‰）には両種は全く分布せずプランクトンはすべて淡水産である。従つて汽水の下限，即ち淡水と汽水との境界は Cl 0.3～0.2‰ におけよう。しかし宮内（1935）は淡水湖と考えられている霞ケ浦においては，*Sinocalanus tenellus* は周年出現するというがこれはむしろ異例に属する。

b）分布限界 Cl 1‰

淡水産の中で塩分に対する適応力の余り強くない種類，即ち *Thermocyclops taihokuensis*, *Cyclops vicinus*, *Alona rectangula*, *Filinia longiseta*, *Polyarthra trigla*, *Asplanchnopus syrinx* は Cl 1‰ 以上の水域には分布しない。一方汽水性種の大部分，即ち *Paracyclopina nana*, *Neomysis japonica*, *Keratella cruciformis* var. *eichwaldi*, *Pedalia fennica*, *Balanus* nauplius larva 等は Cl 1‰ を分布の下限とし，それ以下の水域には侵入していない。従つてこの分布限界 Cl 1‰ の意味は顕著であるといえよう。

c）分布限界 Cl 5‰

この分布限界は極めて顕著である。淡水産の多くの種類，即ち *Eodiaptomus japonicus*

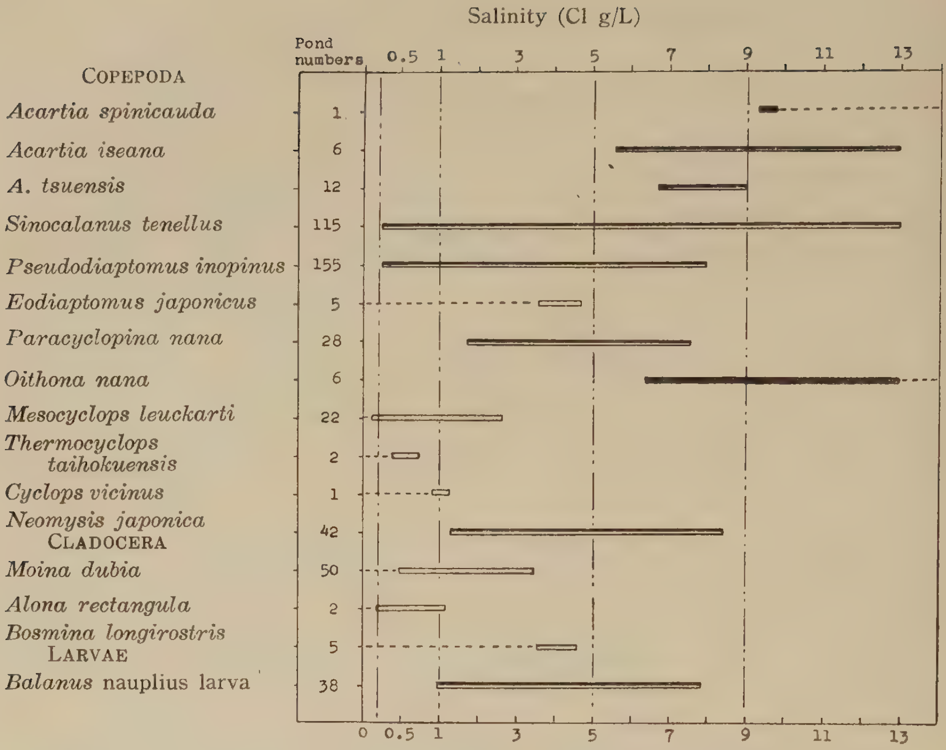


Fig. 3. Distribution ranges of plankton crustacea in brackish-water fish ponds, Mie Prefecture.

Bosmina longirostris, *Brachionus calyciflorus*, *Br. quadridentatus*, *Br. angularis*, *Keratella cochlearis*, *Asplanchna* sp., *Ceratium hirundinella* 等はすべて Cl 5‰ が分布の上限になつている。唯々 *Br. urceolaris*, *Br. quadridentatus*, *Asplanchna* sp. はこの限界をこえているが，その例は稀であり，個体数も極めて少い。

一方海産系の *Acartia iseana*, *A. tsuensis*, *Oithona nana*, *Ceratium macroceros*, *C. furca*, *Favella ehrenbergi*, *Tintinnopsis radix* は Cl 5‰ を分布の下限とし，それ以下の低鹹水域には出現しない。この Cl 5‰ に海産系並に淡水系の分布限界を設定出来よう。

d) 分布限界 Cl 8～10‰

伊勢湾西岸においては Cl 8‰ 以上の水域は少く，調査例も多くないので，この分布限界は明瞭でない。全体的に見ると，大部分の汽水産，*Acartia tsuensis*, *Pseudodiaptomus inopinus*, *Paracyclopina nana*, *Neomysis japonica*, *Brachionus plicatilis*, *Pedalia fennica*, *Balanus* naupius larva はこの Cl 8～10‰ を分布の上限としているようである。一方海産系の *Acartia spinicauda* は Cl 9‰ 以下の水域に侵入していない。従つて伊勢湾西岸の汽水性養魚池群においては Cl 8～10‰ に 1 つの分布限界を想定し得よう。Cl 9‰ にその限界をおくのが妥当のように思はれるが，この点については更に将来の検討が必要である。

e) 汽水の上限

汽水と海水との境界は代表的汽水性橈脚類の *Sinocalanus tenellus*, *Pseudodiptomus*

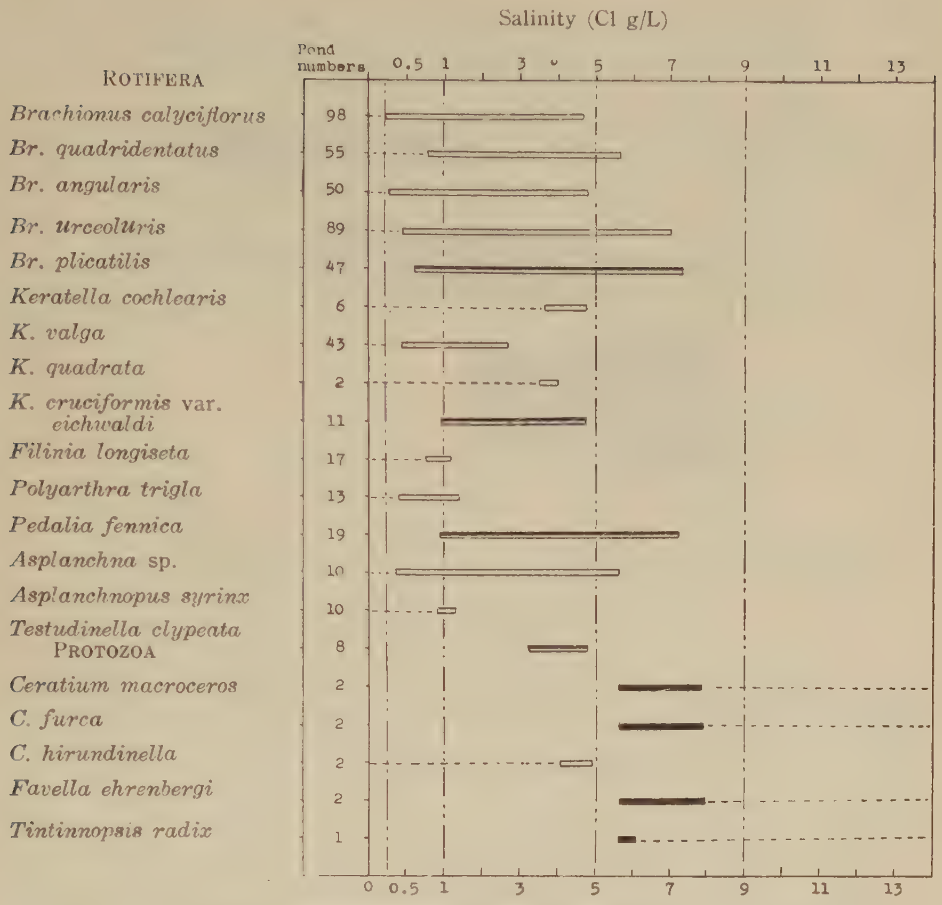
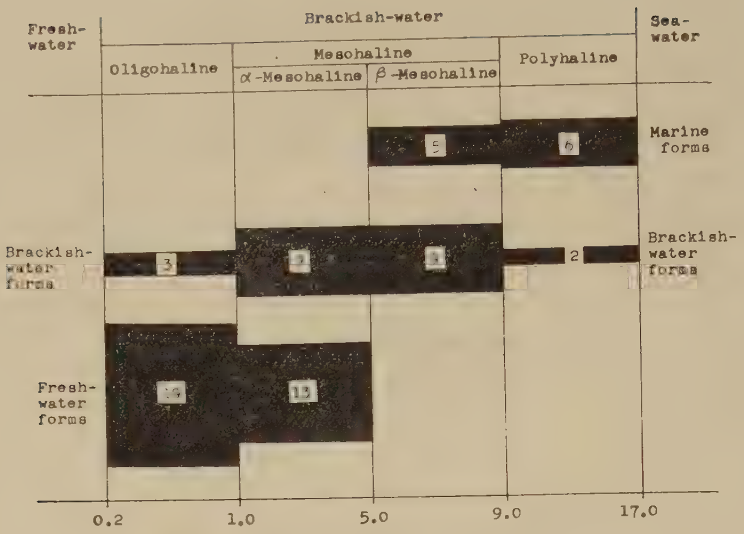


Fig. 4. Distribution rages of plankton rotifer and Protozoa in brackish-water fish ponds, Mie Prefecture.

inopinus が存在し得ることであることが妥当のように思はれる。ところで伊勢湾西岸における両種の分布上限を見ると，*Sincalanus* は Cl 12.928‰ の 1 池に夥しく増殖していたが，この塩分が調査結果では最大で，それ以上の水域は見られなかつた。*Pseudodiaptomus inopinus* の分布の上限は今回の調査では Cl 7.952‰ であつた。このように伊勢湾西岸においては Cl 8‰ 以上の水域は少く，調査例も少く，その上 Cl 12.928‰ 以上の水域は見出されなかつたので，汽水の上限，即ち汽水と海水との境界を決定することは出来ない。小久保・佐藤 (1947) によると十三潟においては *Sinocalanus*, *Pseupodiaptomus* は夫々 Cl 16.15‰, 15.44‰ までの水域に分布することを報告している。従つて汽水の上限は Cl 16～17‰ と決定出来るのではないかと思はれる。

典型的汽水性プランクトンの *Sinocalanus* 並に *Pseudodiaptomus* の棲息範囲を，塩分の点からは Cl 0.2～17‰ を "汽水，Brakish-water" と規定するのが妥当と考える。

上述の伊勢湾西岸の汽水性養魚池におけるプランクトン動物の分布と池水の塩分との関係は稍々模式的に示すと Fig. 5 になる。



Chlorine contents of the pond water (Cl g/L)

Fig. 5. Diagrammatic relation between the distribution of zooplankters and salinity of pond water.
The figure shows the number of species.

上述の伊勢湾西岸の 239 面の汽水性養魚池のプランクトン動物の分布と池水の塩分との関係から帰納した結果を基にして，これらの養魚池群を類型化すると次のようになる。

伊勢湾西岸汽水性養魚池の分類

		Cl ‰
	淡　　水	<0.2
I.	貧鹹性汽水	0.2～ 1.0
II.	中鹹性汽水	1.0～ 9.0
II a.	α-中鹹性汽水	1.0～ 5.0
II b.	β-中鹹性汽水	5.0～ 9.0
III.	多鹹性汽水	9.0～17.0
	海　　水	>17.0

用語は REDEKE のものが妥当と考えられるのでそのまま使用した。訳語は上野 (1934, p. 413) に従つた。全体的に見ると，REDEKE の分類方式が伊勢湾西岸の汽水性養魚池のプランクトン動物—塩分関係にもよく適合することを示している。また伊藤 (1955) が津附近の 73 面の汽水性養魚池から帰納した結果とも殆んど矛盾は見られなかつた。REDEKE (1936) は α-Mesohaline 並に β-Mesohaline を Oligohaline 並に Polyhaline と同格においているが，ここではその 2 つを格下げして，その上位に中鹹性汽水をおき，他と同格にした。理由は中鹹性汽水が狭義の “汽水” で，Figs. 3～5 に明らかのように，ここに多くの汽水性プランクトンが好適の生活環境を見出し，汽水性種については Cl 5‰ に著しい分布限界は存在しないからである。小久保・佐藤 (1947) の提案した “汽水域” (Cl 2～7‰) は中鹹性汽水，即ち狭義の “汽水” に解するならば略々妥当であろう。

この分類方式によつて今回調査した伊勢湾西岸の 239 面の汽水性養魚池は Table 9 のように分類することが出来る。

Table 9. A classification of brackish-water fish-culture ponds on the west coast of Ise Bay, Mie Prefecture, by the plankton fauna-salinity relationship.

Brackish-water / Cl ⁰/₀₀ / Kind of pond	Oligohaline	α-Meso-haline	β-Meso-haline	Polyhaline	Total
	0.2~1.0	1.0~5.0	5.0~9.0	9.0~17.0	
Eel-culture pond (in culture)	21	145	18	0	185
Eel-culture pond (In fallow)	2	4	25	0	31
Natural pond	2	11	8	2	23
Total	25	161	51	2	239

Table 9 に明かのように，養殖中の養鰻池について見ると，全体の80% が α- 中鹹性汽水に属し，貧鹹性並に β- 中鹹性汽水が夫々 10% を占め，淡水並に多鹹性汽水に属するものは存在しない。

2. 各汽水域のプランクトン動物相から見た特異性

I. 貧鹹性汽水 (Cl 0.2~1.0‰)

一般的特徴として淡水系のプランクトン動物かなおここでも卓越的に増殖し，淡水においては稀な種類が往々大増殖をする。ここに見られる淡水系のプランクトン動物としては次のものがある。*Mesocyclops leuckarti*, *Thermocyclops taihokuensis* *Cyclops vicinus*, *Moina dubia*, *Alona rectangula*, *Brachionus calyciflorus*, *Br. angularis*, *Br. quadridentatus*, *Br. urceolaris*, *Kellatella valga*, *Filinia longiseta*, *Polyarthra trigla*, *Asplanchna* sp. *Asplanchnopus syrinx*. しかし一方汽水性プランクトン，*Sinocalanus tenellus*, *Pseudodiaptomus inopinus*, *Brachionus plicatilis* が侵入している点で淡水のプランクトン相と異る。

II. 中鹹性汽水 (Cl 1.0~9.0‰)

狭義の"汽水域"で，純汽水性プランクトンの棲息範囲で，他の 2 つの汽水域には全く分布しないか，或いはその境界附近のみに出現するような種類がここで最適の生態環境を見出している。これは Cl 5‰ を境界として更に次の 2 つの汽水域に分けられる。

II a. α- 中鹹性汽水 (Cl 1.0~5.0‰)

淡水産の中の 1 部，即ち *Br. calyciflorus*, *Br. urcelaris*, *Br. quadridentatus*, *Br. angularis*, *Eodiaptomus japonicus*, *Mesocyclops leuckarti*, *Alona rectangula*, *Bosmina Longirostris*, *Keratella cochlearis*, *K. valga*, *Asplanchna* sp., *Ceratium hirundinella* がなお分布し卓越するが，汽水産種の大部分，即ち *Sinocalanus tellneus*, *Pseudodiaptomus inopinus*, *Paracyclopina nana*, *Neomysis japonica*, *Br. plicatilis*, *Pedalia fennica*, *Keratella cruciformis* var. *eichwaldi*, *Balanus* nauplius larva が量的には最も卓越する。しかし海産系は全く侵入していない。

II b. β-中鹹性汽水 (Cl 5.0~9.0‰)

淡水産のプランクトン動物は殆んど分布せず，汽水産が卓越し，海産の 1 部，即ち

Oithona nana, *Ceratium macroceros*, *C. furca*, *Favella ehrenbergi*, *Tintinnopsis radix* がこの水域まで侵入している。

III. 多鹹性汽水 (Cl 9.0～17.0‰)

海洋の影響の最も大きい汽水域で，プランクトン動物相の主部は海産系より構成されるが，純汽水性の *Sinocalanus tenellus*, *Pseudodiaptomus inopinus* が分布する点で海洋と異る。この範疇に入る伊勢湾西岸の汽水性養魚池の調査例が少いので，この汽水域のプランクトン動物相の特徴は明かでない。全体的に見ると，本邦の他の天然汽水湖のそれに比較すると動物相は貧弱のようである。

VI. 摘 要

1) 本研究は昭和28年9月から昭和29年12月に亘り，伊勢湾西岸に広く分布する養鰻池を主とする 239 面の汽水性養魚池の調査結果に基いたものである。

2) 三重県の養鰻池は伊勢湾西岸の海岸線に膚接し，北は伊曽島から松阪に亘り，又志摩地方の穴川にも存在する。中心地域は城南，川越，楠，津，香良州，松阪地方である。

3) これらの汽水性養魚池はその立地から例外なく相当の塩分を含有し，汽水 (brackish-water) に属する。池水の塩分の最小は Cl 0.232‰，最大は 12.928‰ にして，最も多いものは Cl 1～2‰ で全体の 40% を占め，次は Cl 2～3‰ で 23%，Cl 1<‰ は 11%，Cl 3～4‰ は 10% の順である。しかし Cl 5～8‰ の池水で全体の約 10% が実際に養鰻を行つていることは注目すべきである。これらの池水の塩分は静岡・愛知両県のそれ比較すると全体的に著しく高鹹である。

4) 汽水性養魚池の動物性プランクトンは海産系，汽水系，淡水系の3要素から構成されている。卓越しているのは汽水系，淡水系で，海産系は少い。

5) 海産系のプランクトン動物には *Acartia spinicauda*, *A. iseana*, *A. tsuensis*, *Oithona nana*, *Ceratium macroceros*, *C. furca*, *Favella ehrenbergi*, *Tintinnopsis radix* が見出されたが，量的には多くない。

6) 汽水産には *Sinocalanus tenellus*, *Pseudodiaptomus inopinus*, *Paracyclopina nana*, *Neomysis japonica*, *Brachionus plicatilis*, *Keratella cruciformis* var. *eichwaldi*, *Testudinella clypeata*, *Pedalia fennica*, *Balanus* nauplius larva が見られ，その中では *Sinocalanus*, *Pseudodiaptmus*, *Neomysis*, *Br. plicatilis* が最も卓越し，量的にも豊富である。

7) 淡水系の種類は多い。分布が広く，量的に卓越したものは，*Moina dubia*, *Br. calyciflorus*, *Br. quadridentatus*, *Br. angularis*, *Br. urceolaris*, *Keratella valga* 等である。その他に *Mesocyclops leuckarti*, *Thermocyclops taihokuensis*, *Cyclops vicinus*, *Alona rectangula*, *Bosmina longirostris*, *Keratella cochlearis*, *K. quadrata*, *Filinia longiseta*, *Polyarthra trigla*, *Asplauchnopus syrinx*, *Ceratium hirundinella* が分布するが，量的には重要でない。

8) 養鰻池の水変りには低鹹池 (Cl 0.2～3‰) では淡水産輪虫類の *Brachionus calyciflorus*, 高鹹池 (Cl 2～7‰) では汽水産輪虫類の *Br. plicatilis* の大増殖が見られる。

9) これらの汽水性養魚池の動物性プランクトンは 1~10 種より成り，2~4 種で構成されている場合が全体の約半数を占め，且つ池水の塩分の濃い池程その種数は減少し単純になる傾向がある。淡水湖並に海洋に比してプランクトン動物相は単調である。これは汽水性養魚池の非調和性を物語るものであろう。

10) プランクトン動物の分布と池水の塩分との間には稍々明瞭な関係があり，純汽水性プランクトン *Sinocalanus tenellus*, *Pseudodiaptomus inopinus* の棲息塩分範囲 (Cl 0.2~17‰) を"汽水"と定義することを提案した。この"汽水"は更にプランクトン動物の分布状態によつて，Cl 1, 5, 9‰ によつて細分することが妥当である。

11) 従つてプランクトン動物相・塩分関係からこれらの汽水性養魚池は次のように分類出来る。

		Cl ‰
	淡　　水	<0.2
I.	貧鹹性汽水	0.2~ 1.0
II.	中鹹性汽水	1.0~ 9.0
II a.	α-中鹹性汽水	1.0~ 5.0
II b.	β-中鹹性汽水	5.0~ 9.0
III.	多鹹性汽水	9.0~17.0
	海　　水	>17.0

即ち REDEKE (1922, 1936) の分類方式がこれらの汽水性養魚池にもよく適合することが分る。

12) 上述の分類方式によつて伊勢湾西岸の 185 面の養殖中の養鰻池を見ると，全体の 80% が α-中鹹性汽水に属し，貧鹹性並に β-中鹹性汽水が夫々 10% を占め，淡水並に多鹹性汽水は存在しない。

13) 各汽水域のプランタトン動物相から見た特徴が総括された。

参　考　文　献

GESSNER, V. F. (1933). Die Planktonproduktion der Brackwässer in ihrer Beziehung zur Produktion der Offener See. *Verhandlungen der Internationalen Vereinigung Für theoretische und angewandte Limnologie*. Bd. VI. S. 154~162.

GESSNER, V. F. (1937). Hydrographie und Hydrobiologie der Brackwässer Rügens und das Darss. *Kieler Meeresforschungen*, Bd. 11, S. 1~79.

羽田良禾 (1938 a). 釧路春採湖の特異性，科学，8 (2), 53~54.

(1938 b). 春採湖に於ける生物，科学，8 (2), 54~55.

(1938 c). 釧路春採湖のプランクトン，陸水雑，8 (3/4), 369~409.

——— (1939). 海産及び汽水産輪虫類，動雑，Vol. 51, 496~503.

HADA, Y. (1940). Hydrographical Observations and Plankton Studies of Some Brackish Water lakes on the Okhotsk Sea Coast of Hokkaido in Winter. *Trans. Sapporo Nat. Hist. Soc.* Vol. 16, 147~174.

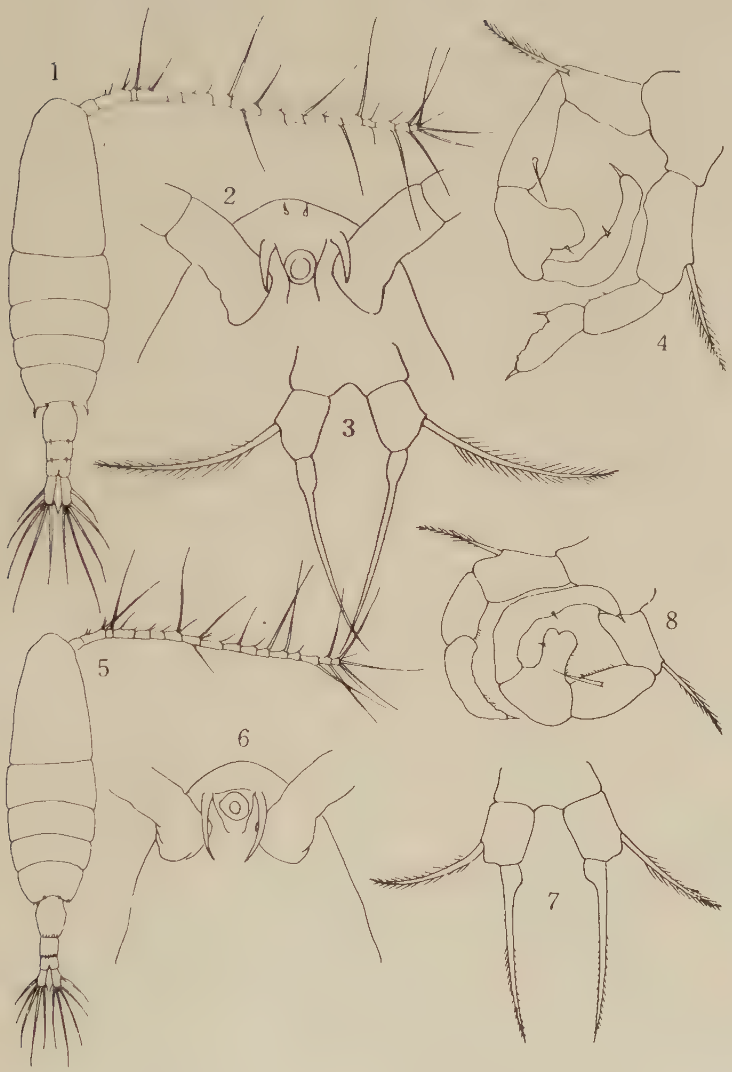
秋田県水産試験場 (1936). 八郎潟水産基本調査書. pp. 51.

井伊直愛 (1954). 日本産アミ類 (Mysidacea) の分類について，水産学の概観，p. 42~107.

石田昭夫 (1950). 網走湖の研究，燐酸塩その他の成層状態に就て，水産孵化場試験報告，Vol. 5, No. 2, p. 113~117.

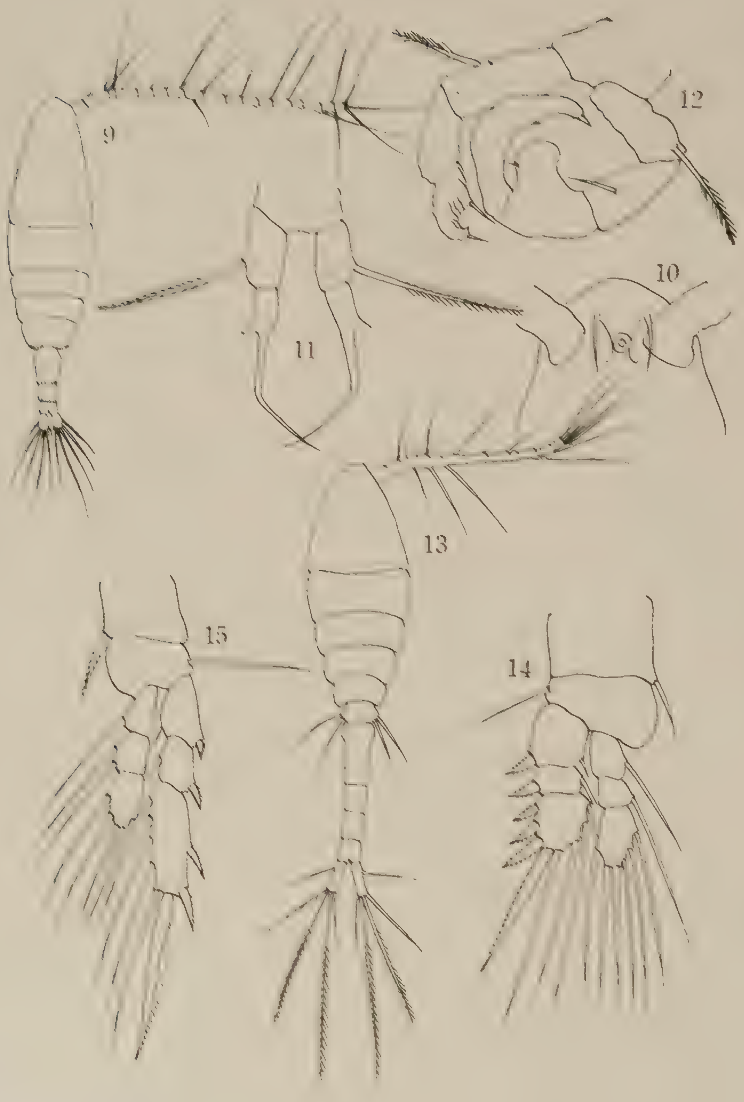
(1952 a). 網走湖の研究，浅い湾内での甲殻類プランクトンの昼夜移動の観察，水産孵化場試験報告，Vol. 7, Nos, 1~2, p. 1~5.

(1952 b). 湖沼観測資料, 水産孵化場試験報告, Vol. 7, Nos. 1〜2, p. 1〜11.
稲葉伝三郎 (1934). 養魚池の水変りとプランクトン, 養殖会誌, Vol. 4, No. 9, p. 159〜164.
稲葉伝三郎・清水定明 (1936). 養鰻池の水変りとプランクトン, II. 水変り前後に於けるプランクトンの消長, 養殖会誌, Vol. 6, Nos. 9〜10. p. 167〜170.
稲葉　峻 (1937). 養鰻池の水変りに関する予察的研究, 魚介類斃死原因調査報告, 第 II 報. 静岡県水産試験場浜名湖分場, pp. 39.
稲葉　峻・山本精二 (1938). 養鰻池に於ける水変りの水質とプランクトンの研究, 魚介類斃死原因調査報告, 第 III 報, 静岡県水産試験場浜名湖分場月報, No. 46, p. 10〜23.
稲葉　峻・清石礼蔵 (1942). 鰻養殖に関する研究, 静岡県水産試験場浜名湖分場, pp. 30.
稲葉伝三郎 (1955). 養鰻池の水変りについて. 鰻のシンポジウム, p. 1〜4. 日本水産学会中部支部.
伊藤　隆 (1955). 三重県養鰻池における水質とプランクトンとの関係. 鰻のシンポジウム, p. 19〜30. 日本水産学会中部支部.
——— (1955 b). 養鰻池の水変りに関する研究. II. Brachionus plicatilis による水変りにおける pH・O_2 の変化. Report of Faculty of Fisheries, Prefectural University of Mie, Vol. 2, No. 1, P. 168〜177.
ITO, T., (1956). Three New Copepods from Brackish-water Lakes of Japan. *Pacific Science*, Vol. X. p. 468〜473.
KIKUCHI, K. (1931). Formation of lateral spine in Brachionus pala. *Jour. Fac. Sc. Tokyo Imp. Univ.*
(1928). Freshwater Calanoida of Middle and Southwestern Japan, *Mem. Coll. Sci. Kyoto Imp. Univ.*, Ser. B, Vol. IV, No. 1, p. 65〜79.
——— (1936). Fresh-water and Brackish-water Calanoid Copepods of Japan with Notes on their Geographical Distribution. *Bull. Biogeograph. Soc. Japan*, Vol. 6, No. 29, p. 275〜284.
菊池健三 (1939). 輪虫類・腹毛類, 岩波講座, 生物学 (動物学), pp. 30.
神戸海洋気象台 (1935). 甑島湖沼群湖沼観測報告. 海洋時報, Vol. 8, No. 2, p. 163〜199.
(1943). 宍道湖湖沼観測報告, 海洋時報, Vol. 13, No. 4, p. 95.
小久保清治 (1944). 湖沼のプランクトン. 生物学の進歩, No. 2, p. 375〜454.
小久保清治・田村　正・阿部　襄 (1931). 恐山湖の生物学的研究概報. 斎藤報恩会時報 59, 1〜22.
小久保清治・佐藤正 ; (1947). 十三潟のプランクトン. 生理生態, Vol. 1, No. 4, p. 1〜16.
楠木義明 (1937). 春採湖調査報告. 陸水雑, 7 (2), 68〜77.
益子帰来也 (1949). 河北潟の研究, 予報 II. 陸水雑, Vol. 14, p. 7〜12.
—— (1950). 日本海の孤島, 舳倉島の陸水概報, 陸水雑, Vol. 15, p. 25〜29.
益子帰来也・野崎啓一・井下　実 (1951). 邑知潟のプランクトンの研究, 生態学研究, Vol. 13, No. 1, p. 12〜15.
MASHIKO, K. and INOUE, A., (1952). Limnological Studies of the Brackish-water Lakes in the Hokuriku District, Japan. *Special Publication of the 3rd Anninersary of its Founding*. p. 175〜191.
益子帰来也 (1954 a). 半鹹水橈脚類に関する一考察, 日本生態学会誌, Vol. 4, No. 1, p. 13〜16.
MASHIKO, K., (1954 b). On the Geographical Distribution of Some Brackish and Fresh-water Copepods in and around Japan. *Science Reports of Kanazawa University*, Vol. 2, No. 2, p. 1〜7.
宮地伝三郎 (1933). ミシス科の痕跡動物に就いて, 日水会誌, Vol. 1, No. 6, p. 291〜298.
MORI, T., (1937). The Pelagic Copepoda from the Neighbouring Waters of Japan. pp. 150.
元田　茂 (1950). 北海道湖沼誌, 水産孵化場試験報告 (湖沼特集号), Vol. 5, No. 1, p. 1〜96.
元田　茂・石田昭夫 (1950). 夏季網走湖に於ける甲殻類プランクトンの昼夜垂直移動の観察, 水産孵化場試験報告, Vol. 5, No. 2, p. 105〜112.
—・——— (1948). 網走湖の研究特にプランクトン相に就て (第 1 報). 水産孵化場試験報告, Vol. 3, No. 1, p. 1〜12.
・ (1949). 網走湖の研究特にプランクトン相に就て (第 2 報). 水産孵化場試験報告, Vol. 4, No. 1, p. 1〜9.
宮内武雄 (1935). 霞ケ浦のプランクトン, 陸水雑, Vol. 5, p. 26〜32.
中村中六 (1948). 海岸地方に於ける養魚池の塩分含有量とコヒ・フナの生活及び生産量との関係, 東大立地自然科学研究所報告, No. 1, p. 51〜67.

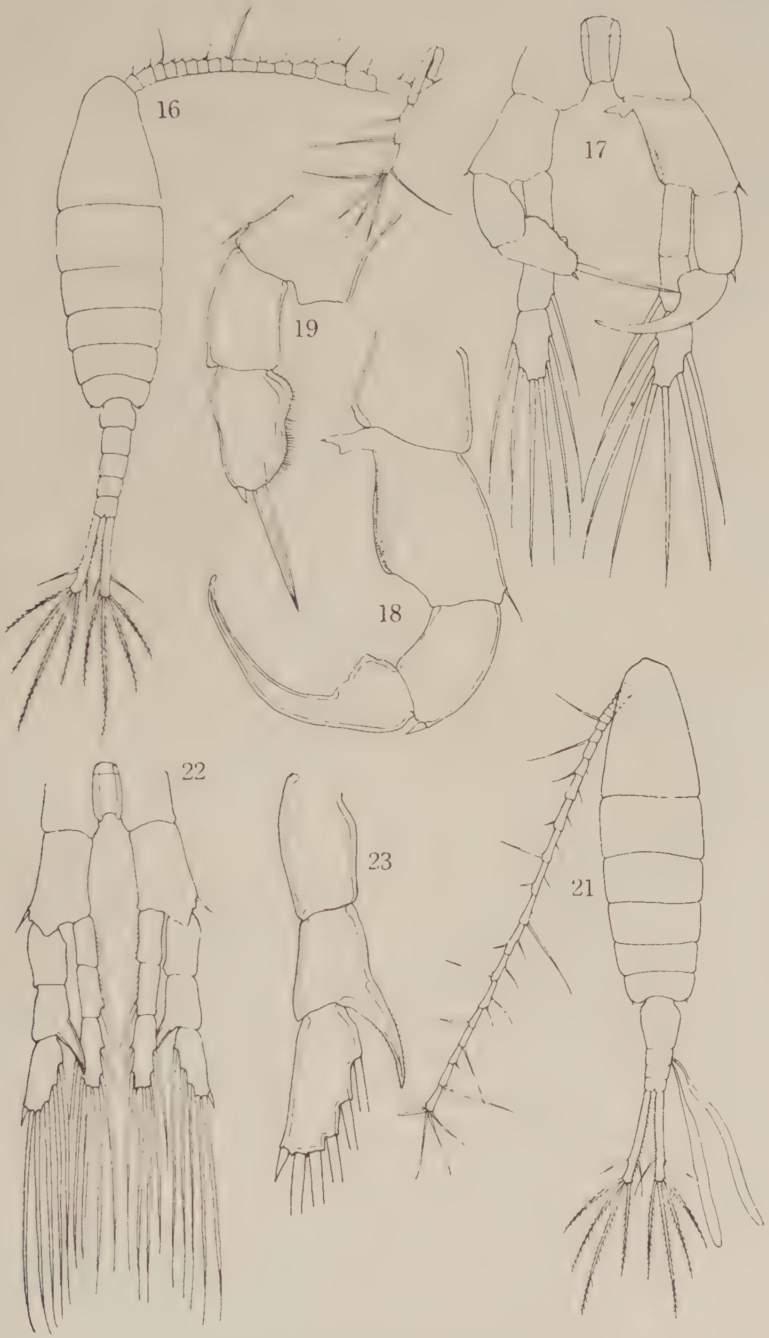


Figs. 1–4. *Acartia spinicauda* GIESBRECHT
1. Female (dorsal); 2. Female, forehead;
3. Female, leg 5; 4. Male, leg 5.

Figs. 5–8. *Acartia iseana* ITO
5. Female (dorsal); 6. Female, forehead;
7. Female, leg 5; 8. Male, leg 5



Figs. 9–12. *Acartia tsuensis* Ito
9. Female (dorsal); 10. Female, forehead;
11. Female, leg 5; 12. Male, leg 5.
Figs. 13–15. *Oithona nana* Giesbrecht
13. Female (dorsal); 14. Leg 1;
15. Leg 4.



Figs. 16–23. *Sinocalanus tenellus* (KIKUCHI)

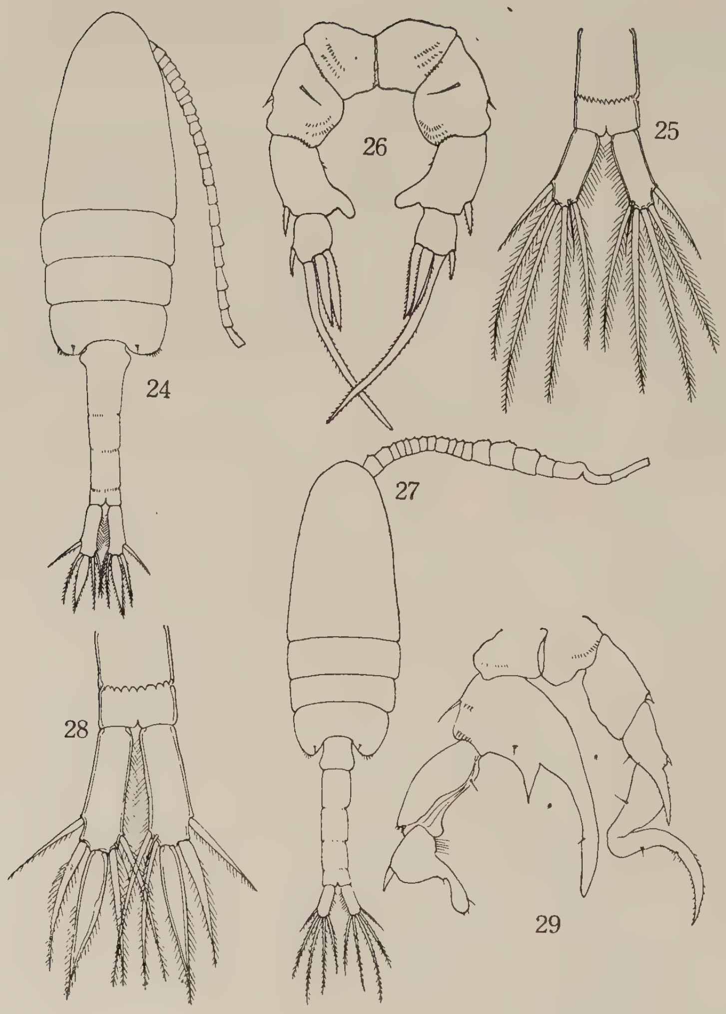
16–19. Male; 21–23. Female.

16. Male (dorsal); 17. Leg 5;

18. Right leg 5; 19. Left leg 5;

21. Female (dorsal): 22. Leg. 5;

23. Expodite of leg 5.



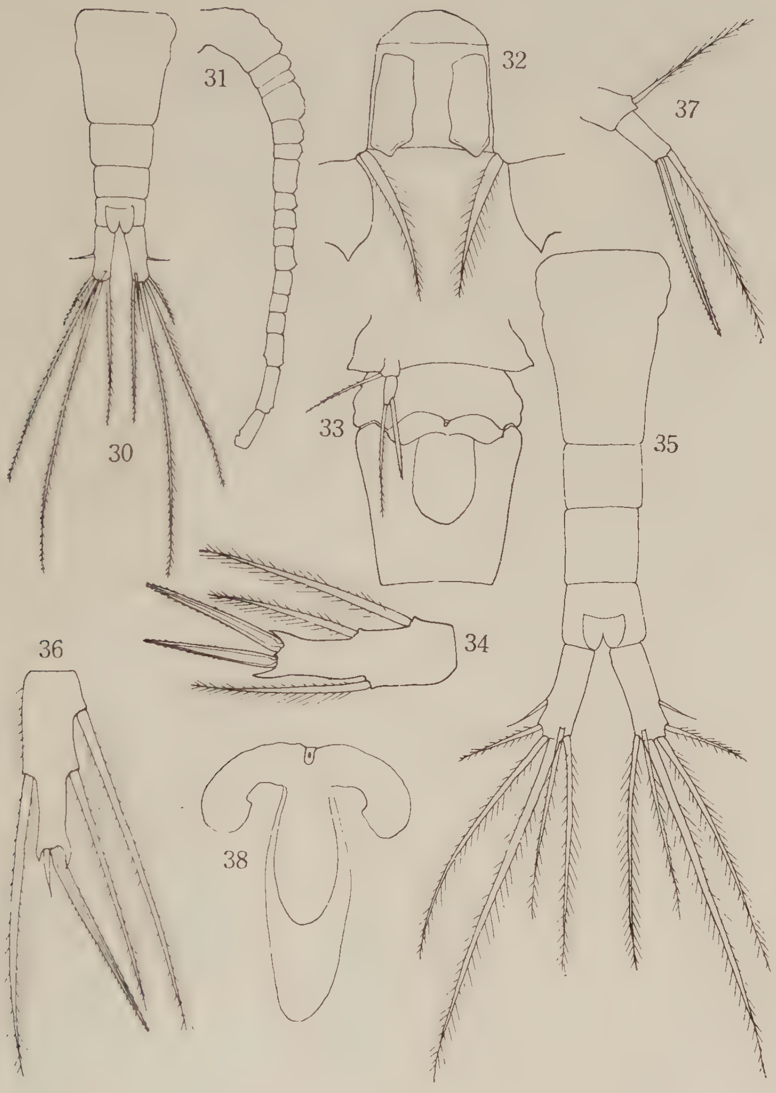
Figs. 24–29. *Pseudodiaptomus inopinus* BURCKHARDT

24, 26, 28. Female; 25, 27, 29. Male.

24. Female (dorsal); 25. Furca and furcal setae;

26. Leg 5. 27. Male (dorsal);

28. Furcal rami and setae; 29. Leg 5.

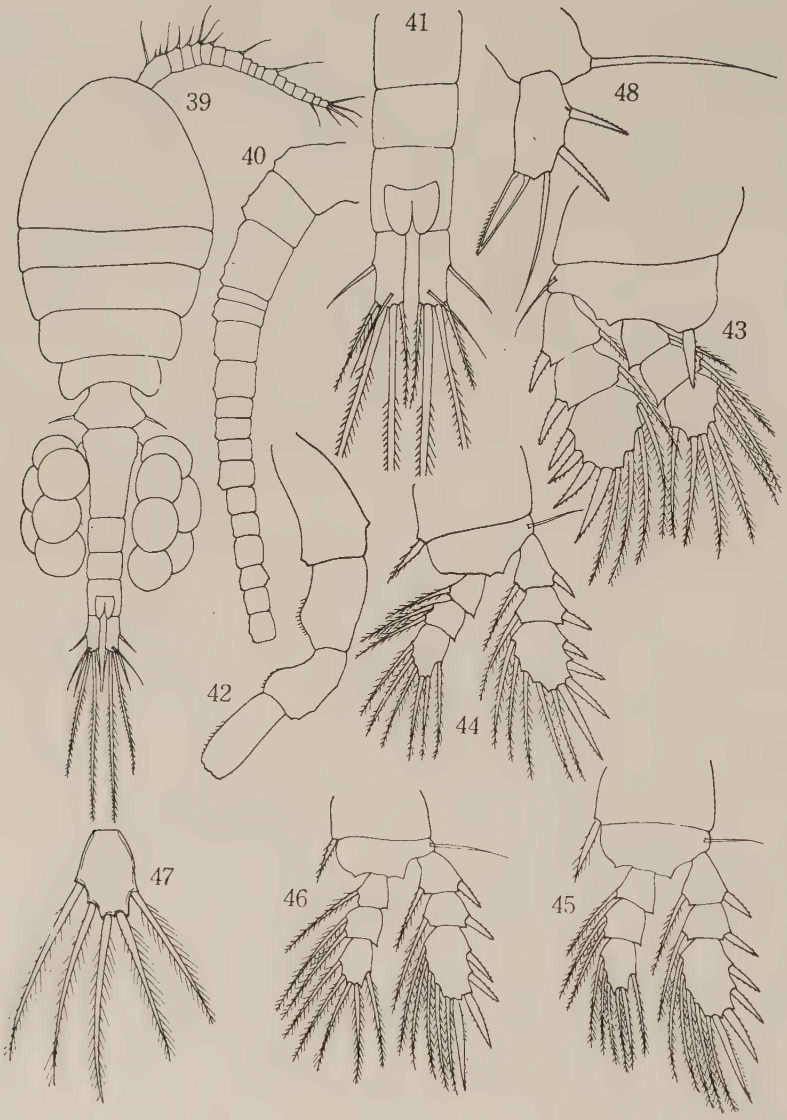


Figs. 30–34. *Mesocyclops leuckarti* (CLAUS)

30. Abdomen and furca;
31. First antenna;
32. Connecting plate of leg 4;
33. Leg 5 and Receptaculum seminis;
34. Last segment of endopodite in leg 4.

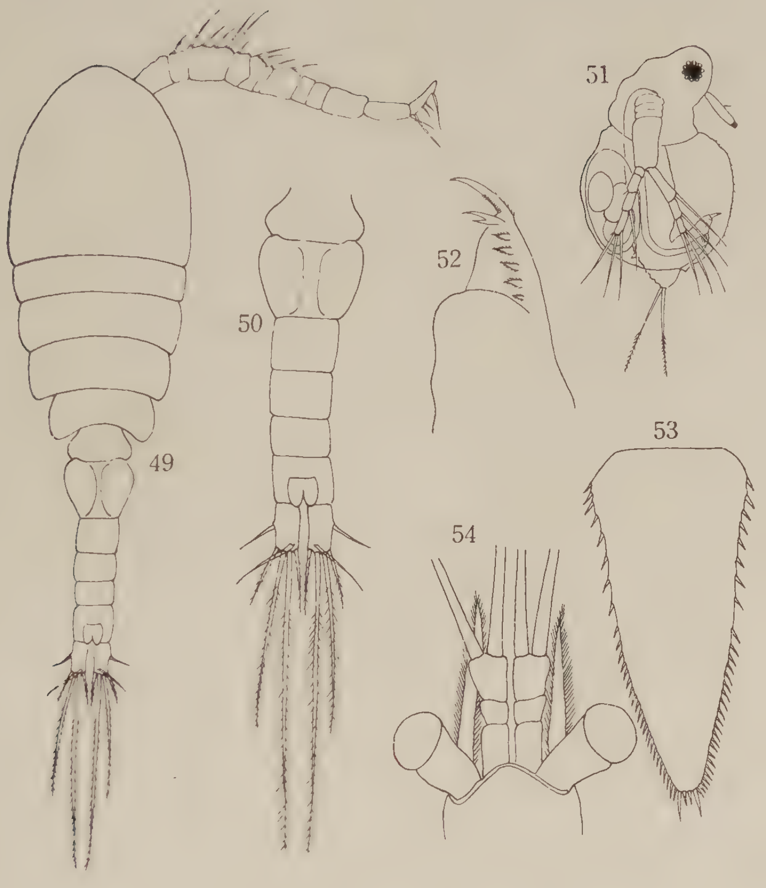
Figs. 35–38. *Thermocyclops taihokuensis* (HARADA)

35. Abdomen and furca;
36. Last segment of endopodite in leg 4;
37. Leg 5;
38. Receptaculum seminis.



Figs. 39–48. *Paracyclopina nana* SMIRNOV (Female)

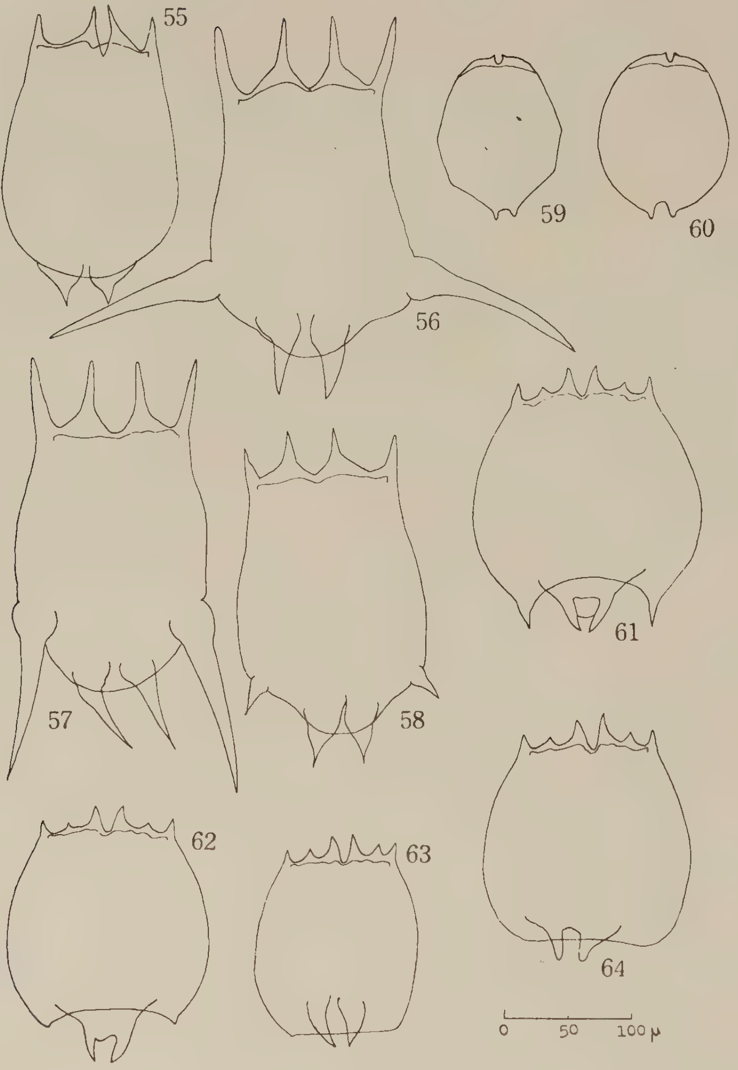
39. Female (dorsal);
40. First antenna;
41. Furcal rami and setae;
42. Second antenna;
43. Leg 1;
44. Leg 2;
45. Leg 3;
46. Leg 4;
47. Last segment of endopodite in leg 4;
48. Leg 5.



Figs. 49–50. *Paracyclopina nana* SMIRNOV (male)
49. Male (dorsal); 50. Abdomen and furca.

Figs. 51–52. *Moina dubia* DE GUERNE et RICHARD
51. Female; 52. Post abdomen.

Figs. 53–54. *Neomysis japonica* (NAKAZAWA)
53. Telson; 54. Forehead.



Figs. 55–58. *Brachionus calyciflorus* PALLAS

55. s. str.; 56. forma *amphiceros* EHRENBERG;

57. f. *amphiceros* EHRENB. 58. f. *anuraeiformis* BREHM.

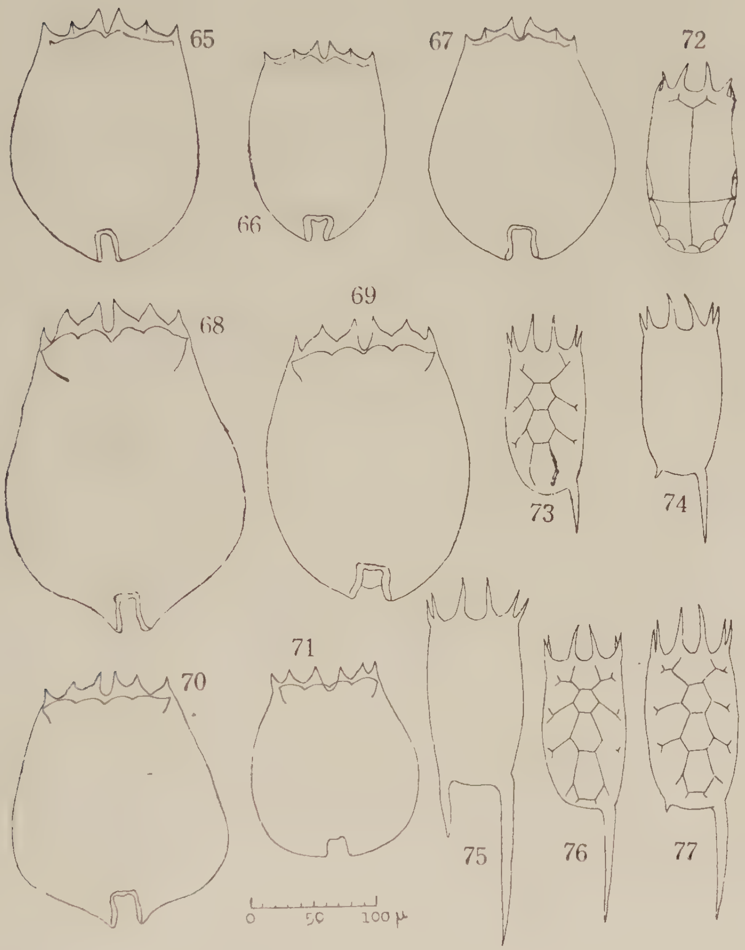
Figs. 59–60. *Brachionus angularis* GOSSE

59. s. str.; 60. var. *bidens* PLATE.

Figs. 61–64. *Brachionus quadridentatus* HERMANN

61. var. *brevispinus* EHRENB.; 62. var. *entzii* (FRANCE);

63. var. *rhenanus* (LAUTERBORN); 64. var. *cluniorbicularis* (SKORIKOV).



Figs. 65–67. *Brachionus urceolaris* O. F. MÜLLER
Figs. 68–71. *Brachionus plicatilis* O. F. MÜLLER
Fig. 72. *Keratella cruciformis* var. *eichwaldi* (LEVANDER)
Figs. 73–77. *Keratella valga* (EHRENBERG)
73. f. *monstrosa* (BARROIS and DADAY);
74. f. *asymmetrica* (BARROIS and DADAY);
75. f. *tropica* APSTEIN;
76. f. *tropica-monstrosa* (APSTEIN-BARROIS and DADAY);
77. f. *tropica-asymmetrica* (APSTEIN-BARROIS and DADAY),

(1949). 伊川津附近の養魚池塩分量の季節的変化，東大立地自然科学研究所報告，No. 2, p. 37～41.

(1955). アオコの濃さと水中の明るさ，鰻のシンポジウム，p. 9～17. 日本水産学会中部支部.

(1955). 静岡・愛知・三重，各地方養鰻池の水色，透明度，塩分量一覧表（プリント).

RAWSON, D. S. and J. E. Moore (1944). The Saline Lakes of Saskatchewan. *National Research Council of Canada.* Vol. 22, p. 141～201.

REDEKE, H. C., (1922). Bijdragen tot de Diurkunde, Afl. 22. (THIENEMANN, 1925, Die Binnengewässer Mitteleuropas. die Binnengewässer. Bd. 1, S. 224～227).

(1936). On the Present State of Our Knowledge of Limnology in the Netherlands. *Union Géodésique et Geophysique Internationale Rapports divers.* p. 1～16.

SMIRNOV, S., (1935). Zur Systematik der Copepoden-Familie Cyclopinidae G. O. Sars. *Zool. Anz.*, 109, 203～210.

佐藤月二 (1941). 朝鮮東海岸の一汽水湖の生物，陸水雑，Vol. 11, p. 85.

高安三次・五十嵐彦仁・沢 賢蔵 (1930 a). 湖沼調査（涛沸湖). 水産調査報告，21, 93～117.

(1930 b). 湖沼調査（小向沼). 水産調査報告，22, 93～106.

——— (1930 c). 湖沼調査（網走湖). 水産調査報告，22, 1～61.

——— (1933). 湖沼調査（頓別沼). 水産調査報告，28, 1～55.

— (1934 a). 湖沼調査（さろま湖)，水産調査報告，34, 1～63.

(1934 b). 湖沼調査（湧洞沼，温根沼，能取湖). 水産調査報告，36, 1～23, 25～47, 49～83.

上野益三 (1934 a). 国後島西南部湖沼のプランクトン，陸水雑，Vol. 3, No. 4, p. 129～133.

上野益三 (1934 b). 藻琴沼とその生物（北海道の陸水とその生物群聚，予報の 3). 植物及び動物. Vol. 5, No. 7, p. 1261～1268.

(1937). 鰓脚目，甲殻綱，日本動物分類，Vol. 9, No. 1, pp. 135.

UENO, M., (1938). Stratification of Noctiluca in a Brackish Water Lake of Hokkaido, Japan. *Proc. Imp. Acad. Tokyo*, Vol. XIV, No. 6, p. 231～232.

上野益三 (1943). 日本の汽水湖特に潟湖の生態学的研究，第 1 報，服部報公会研究報告， No. 10, p. 409～425.

——— (1951). 人工湖におけるプランクトンの発生とその変移，水道協会雑誌，No. 198, p. 9～19.

山元孝吉 (1949). 日本陸水産輪虫類 (2). 陸水雑，Vol. 14, p. 91～98.

——— (1951). 日本陸水産輪虫類 (6). 陸水雑，Vol. 15, p. 81～87.

——— (1952). 日本陸水産輪虫類 (7). 陸水雑，Vol. 16, p. 24～30.

Appendix

Plate XXV～XXXIII

伊勢湾西岸養鰻池の主要動物性プランクトン

Report of Faculty of Fisheries,
Prefectural University of Mie,
Vol. 2, No. 3, July 30, 1957.

養鰻池の水変りに関する研究

VI. Brachionus plicatilis の増殖とプランクトン植物量との関係*

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(三重県立大学水産学部陸水学教室)

Studies on the "Mizukawari" in Eel-culture Ponds

VI. The Relations between the Growth of Brachionus plicatilis and the Quantity of Phytoplankton

(*With 3 Text-figures and 3 Tables*)

TAKASHI ITO

Résumé

1) This experiment has been carried on to clarify the following three points in the laboratory: the relation of the growth of a brackish-water rotifer, *Brachionus plicatilis* O. F. MÜLLER with the quantity of phytoplankton as the food source, the relation of the population density of the rotifer at the starting point with the following growth of it, and the quantity of dormant eggs formed.

2) As the supply of phytoplankton increases, the population density of *Br. plicatilis* and the rate of death after attaining the maximum population density of it also becomes bigger. (Table 1 and Fig. 1.)

3) To the relation of the maximum population density of *Br. plicatilis* (individual numbers/cc, X) and the quantity of phytoplankton (cell numbers/cc, Y), $Y=aX^b$ is applied ; in this case, a=20071, b=1.452. (Fig. 2.)

4) Consequently, from 2) and 3), there it comes that the quantity of phytoplankton is the larger, so is the population growth of *Br. plicatilis*, and accordingly so is the speed and changing range of "Mizukawari", and there also is the possibility of the increasing degree of " Mizukawari ".

5) The influence of the population density of *Br. plicatilis* at the starting point upon its following growth is not distinct, but taking as a whole, with those of the larger population density, the growth speed is also high and reach its saturation density in a shorter time. But if the quantity of phytoplankton as the food source is same, the height of saturation density of the rotifer is also equal. (Fig. 3 and Table 2).

6) The formation of the dormant eggs of *Br. plicatilis* in its growth period is distinct. The quantity of the dormant eggs has a close relation with the quantity of phytoplankton as the food source of the rotifer, but no close relation with the population density at the starting point. When the phytoplankton is chiefly composed of *Merismopedia tenuissima* (blue-green algae), and the green pond water containing 34.24×10^6 cells/cc is used as its medium, the formation of the dormant eggs is 12.6-18.8/cc, and is about 7-11% of the maximum population density of the whole living rotifers. (Table 3.)

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* 本研究の大要は昭和 31 年 4 月日本水産学会大会(東京)で講演した。

第1・2・5報[1) 2),3)]の結果から，輪虫類の大増殖とその顕著な植物性プランクトンの捕食作用によつてひきおこされる“水変り”の程度と速度は，当然輪虫の増殖速度と増殖量に支配され，また輪虫の増殖は餌料としての植物性プランクトンの量と密接な関係があると考えられる。養鰻池における“水変り”の程度に関与する諸要因解明の基礎問題として，*Brachionus plicatilis* O. F. Müller の増殖とプランクトン植物量並に出発点におけるこの輪虫の個体数密度とその後の増殖との関係，及び耐久卵の形成量を明かにするために本実験を行つた。

本実験に対し種々の助言を与えられた本学水産学部長岡田弥一郎教授に謝意を表します。本研究は昭和30年度文部省科学研究助成金によつたものである。

材料並に方法

輪虫の材料は第5報と同じもので，養鰻池から採集した *Brachionus plicatilis* である。池水並に植物性プランクトンの試料も第5報と同じで，藍藻類の *Merismopedia tenuissima* を優占種とし，植物性プランクトンの細胞数は 34.24×10^6 細胞/cc で，大きさの組成は *Br. plicatilis* の捕食可能限界の 12～15 μ 以下のものが全体の約97%を占めた緑色池水を用いた。

輪虫の増殖は個体数計数によつた。各三角フラスコをよく振盪しながら，駒込ピペットで 5 cc を抽出し，沈澱管に移し，フォルマリン5滴を加えて遠心分離器にかけて沈澱させ，計数盤に移し，その中の全個体数を計数し，培養液 1 cc 中の個体数を算出した。

実験結果

1. Brachionus plicatilis の増殖とプランクトン植物量との関係

前記の藍藻類の *Merismopedia tenuissima* を優占種とし，34.24×10^6 細胞/cc を含んだ透明度 12 cm，緑色を呈し，しかも動物性プランクトンを取除いた養鰻池水に，それと同塩分 (Cl=3.55‰) の稀釈海水を加えて，プランクトン植物量が 1, 1/2, 1/5, 1/10, 1/20, 1/50, 0 (稀釈海水)の7種の濃度にした。各培養液を 200 cc 容量の三角フラスコに 200 cc 入れ，1日放置して後，各フラスコに *Br. plicatilis* を培養液1ccについて1個体の割合に加えた。その後14日間に亘り *Br. plicatilis* の個体数密度の変化を追跡した。*Merismopedia* 池水に輪虫を加えないものを Control とし，一連のフラスコを実験室内の南窓側においた。輪虫のサンプリングは同一のフラスコについて行つたので，それがその後の増殖にいく分影響するのではないかと考えられるが，この点は考慮しなかつた。この実験結果は Table 1 並に Fig. 1 及び Fig. 2 に示した。

プランクトン植物量1並に 1/2 のフラスコでは *Br. plicatilis* の捕食作用により3日後から著しく澄みはじめ，5～6日後には殆んど透明になり，水色も緑色→黄褐色→無色の変化系列をとつた。しかしプランクトン植物量 1/5 以下のフラスコでは水色，透明度の変化は徐々で明瞭でなかつた。*Br. plicatilis* の増殖速度並に増殖量は餌料としてのプランクトン植物量と密接な関係のあることは Table 1 並に Fig. 1 に明かである。プランクトン植物量 1, 1/2, 1/5, 1/10, 1/20 等の濃度の大きいフラスコでは，*Br. plicatilis* の最大個体数密度はいづれも4日後にあり，5～6日後から急激に死滅し，大部分のもの

Table 1. The relation between the population growth of *Brachionus plicatilis* and the quantity of phytoplankton as the food source.
The figures in the table show the number of individuals, *Br. plicatilis* per cc. Water temperature: 22.8–27.4°C.

Quantity of Phytoplankton		Culture days								
Concentration	Cell Numbers/cc	0	2	4	5	6	8	10	12	14
1 (Green pond water)	34.24×10^6	1	38.6	164.0	155.2	147.6	98.0	40.2	25.6	8.6
1/2	17.12	1	23.6	110.4	93.2	83.2	56.0	3.2	0.5	0
1/5	6.85	1	21.8	54.0	47.2	44.8	23.4	2.4	0	0
1/10	3.42	1	16.2	30.2	29.4	20.8	12.4	1.8	0	0
1/20	1.71	1	14.8	19.2	11.6	10.2	0.2	0.2	0	0
1/50	0.68	1	13.6	9.8	8.4	3.4	0	0	0	0
0 (Diluted sea-water)	0	1	8.6	4.0	1.6	0.4	0	0	0	0
Control (No rotifer)	34.24	0	0	0	0	0	0	0	0	0

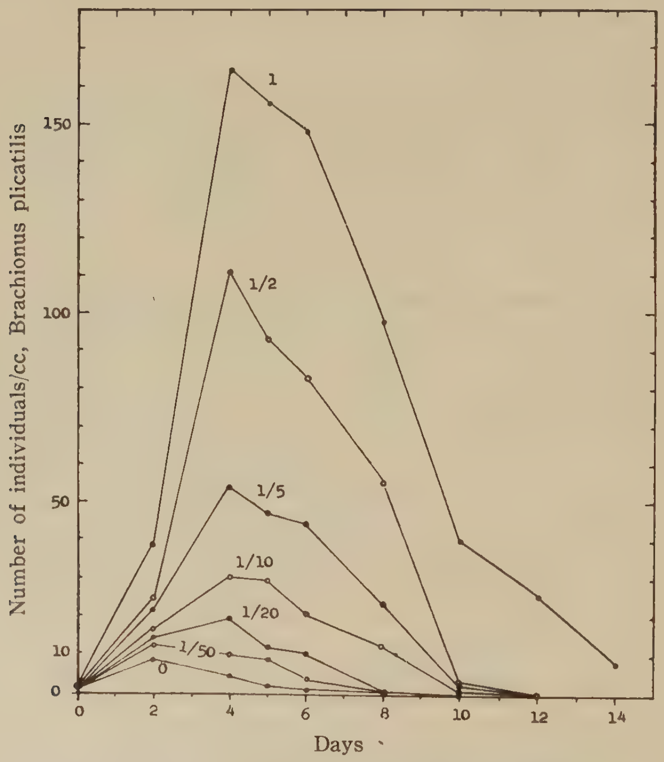

Fig. 1. The relation between the growth of *Br. plicatilis* and the quantity of phytoplankton as the food source.

The figures, 1–1/5–0, indicates the relative quantities of phytoplankton, it dominantly consists of a blue-green alga, *Merismopedia tenuissima*. The medium "1" contains 34.24×10^6 cells/cc of all phytoplankters.

では10日後には生存個体は全く見られなくなるが，植物量1のみでは2週間後にもなお8.6個体/cc が生存していた。植物量1/50並に稀釈海水では，最大個体数密度は夫々13.6, 8.6個体/cc で，共に2日後に見られる。稀釈水海におけるこの増殖は最初に加えた♀♀の携帯した amictic egg が孵化したものであり，新に形成された amictic egg からの増殖は疑わしい。

Br. plicatilis の増殖速度は餌料としてのプランクトン植物量の多いもの程大きいことは Fig. 1 に明かである。また *Br. plicatilis* の増殖量とプランクトン植物量との関係を明かにするために，*Br. plicatilis* の最大個体数密度と出発点におけるプランクトン植物の細胞数/cc との関係を図示すると Fig. 2 になる。プランクトン植物量が 20×10^6 細胞/cc 以下の濃度では *Br. plicatilis* の増殖は植物量と略々比例的であるが，20×10^6 細胞/cc 以上では輪虫の増殖は *Br. plicatilis* 自身の密度効果のためかいく分減少する傾向がある。従つて全体的に見ると両者の関係は直線的ではなくて，指数関係が適用され，

$$Y=aX^b$$

で表現され，この場合には，

$$Y=20071X^{1\cdot452}$$

で示すことが出来る。但し Y はプランクトン植物量(細胞数/cc), X は *Br. plicatilis* の最大個体数密度(個体/cc), a 並に b は夫々常数である。

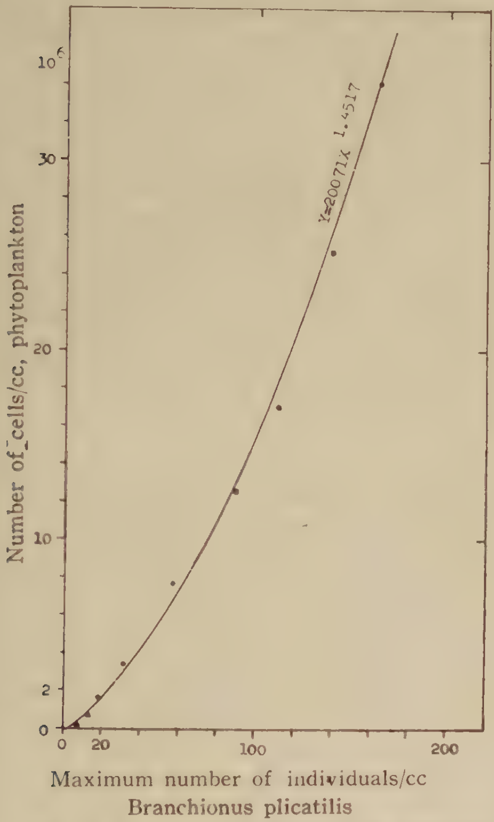

Fig. 2. The relation between the maximum population density of *Br. plicatilis*/cc (X) and cell numbers of phytoplankters (Y) as the food source.

養鰻池の植物性プランクトンが *Br. plicatilis* の捕食限界 12～15 μ 以下の，所謂 micron-algae から構成されている場合には，Fig. 2 並に上述の関係式から *Br. plicatils* の可能増殖量を略々推定出来よう。また上述の結果から，*Br. plicatilis* の増殖速度，増殖量，斃死速度は餌料としてのプランクトン植物量の多い池程大きいということが出来る。このことは餌料としてのプランクトン植物量の多い程，*Br. plicatilis* による"水変り"の変化速度・変化量も大きく，従つて水変りの程度も大きくなる可能性を暗示するものである。なおこの実験結果は *Br. plicatilis* の増殖と植物性プランクトンとの不可分の関係を裏付けるものであろう。

2. Br. plicatilis の最初の個体数密度とその後の増殖との関係

上記の藍藻類の *Merismopedia tenuissima* を優占種とし，34.24×10^6 細胞/cc を含んだ緑色の養鰻池水 (Cl=3.55‰) を培養液とし，200 cc 容量の三角フラスコに 200 cc と

Table 2. The relations between the initial population density and the growth of *Brachionus plicatilis*.
The figures in the table indicate the number of individuals of *Br. plicatilis* per cc. Water temperature: 22.8–27.4°C.

Initial population density of *Br. plicatilis*/cc	Medium: green pond water cells/cc	Culture days								
		0	2	4	5	6	8	10	12	14
0.05	34.24×10^6	0.05	2.0	7.2	40.4	86.4	172.8	133.6	94.0	40.0
0.1	〃	0.1	2.6	23.2	56.4	90.4	173.2	132.4	86.8	38.4
1.0	〃	1.0	28.2	138.0	164.0	137.6	107.2	58.8	35.8	12.4
10.0	〃	10	31.0	120.8	179.2	172.8	90.4	47.2	25.2	9.8
30.0	〃	30	78.2	126.8	204.8	184.0	75.6	27.2	12.4	6.2
Control (No rotifer)	〃	0	0	0	0	0	0	0	0	0

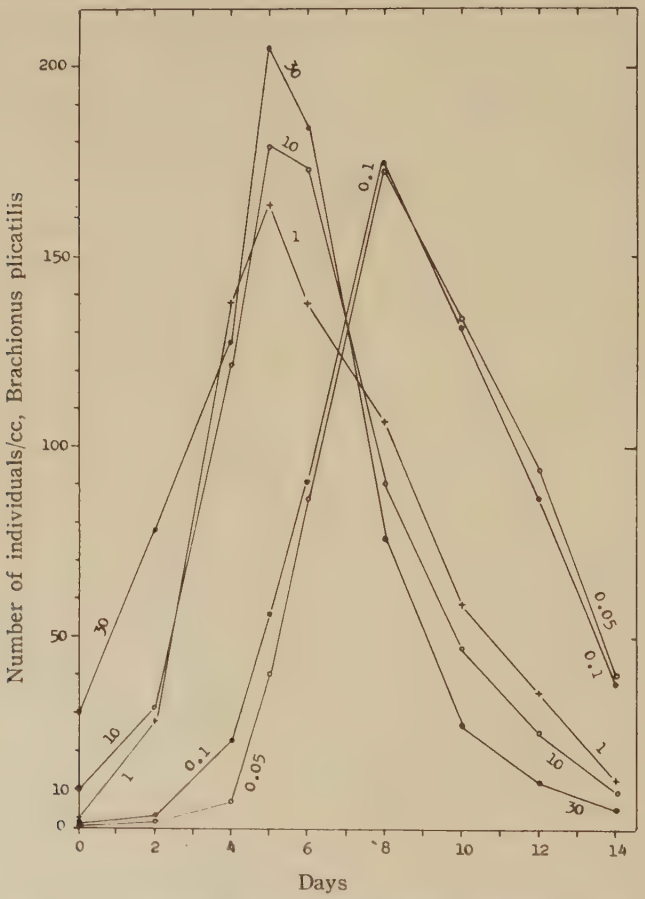

Fig. 3. The relation between the initial population density and the growth of *Br. plicatilis* itself.

The figures, 30–0.05, shows the population density of *Br. plicatilis* at the starting point.

Culture medium: green pond water, contains 34.24×10^6 cells of phytoplankton/cc, it mainly consists of a blue-green alga, *Merismopedia tenuissima*.

り，各フラスコに前記の *Br. plicatilis* を 1cc について 0.05, 0.1, 1, 10, 30 個体の割合に加え，その後の *Br. plicatilis* の増殖，斃死状況を 2 週間に亘つて追跡した。

この場合の水色の変化系列も，緑色 → 黄緑色 → 黄褐色 → 褐色 → 無色であつた。*Br. plicatilis* の増殖に対する出発点における個体数密度の影響は，Table 2 並に Fig. 3 に明かのように，プランクトン植物量との関係程には明瞭でない。その増殖様式には2つの型が見られる。第1は個体数密度 1, 10, 30/cc で，出発点の密度は異つているが，その後の増殖は略々同じ傾向をたどり，いづれも 5 日後に最大個体数密度になり，夫々 164, 179, 205 個体/cc に達した。6 日後からいづれも急激に斃死し，2 週間後には殆んど死滅した。第 2 の型は個体数密度 0.1, 0.05/cc で，4 日後までは潜伏期で増加は殆んど見られないが，5 日後から急激に増殖し，8 日後に最大個体数密度になり，いづれも 173 個体/cc に達した。その後は急激に死亡し，2 週間後には夫々 40, 38 個体/ccに減少した。従つて第 1 と第 2 の増殖様式の相異は位相が 4 日程後者がおくれている点であり，最大個体数密度は第1型の平均は 182.7 個体/cc，第 2 型は 173 個体/cc で大差はない。結局餌料としての植物性プランクトン量が同じならば，出発点における輪虫の個体数密度によつてその増殖様式並に位相も異るが，その植物量に相当した最大個体数密度に到達し，飽和密度の高さは略々一定になることは注目すべき事柄であろう。

Br. plicatilis の耐久卵の形成量について

Br. plicatilis の増殖時に顕著な耐久卵の形成の見られることは既に第 5 報[3]に述べた。本実験においてその耐久卵の形成量を調べた。即ち前述のプランクトン植物量の異つた培養液並に出発点における *Br. plicacilis* の個体数密度を異にする各種条件の三角フラスコ中に2週間に形成され沈積した耐久卵を14日後に各フラスコをよく振盪しながら，

Table 3. The dormant eggs of *Brachionus plicatilis* produced under various conditions in the laboratory during a course of the "Mizukawari". Medium: green-pond water, it mainly consists of a blue-green algae, *Merismopedia tenuissima*. Water temperature: 22.8–27.4°C.

Condition	Dormant egg Numbers/cc (a)	Maximum density of *Br. plicatilis*/cc (b)	Formation rate 100 a/b %	Dormant eggs per cm² of the bottom
Quantity of Phytoplankton				
0 (Diluted sea-water)	0.6	8.6	7.0	2.8
1/50	0.6	13.6	4.4	2.8
1/20	0.6	19.2	3.1	2.8
1/10	1.0	30.2	3.3	4.8
1/5	0.6	54.0	1.1	2.8
1/2	3.4	110.4	3.1	16.4
1 (Green pond water)	12.6	164.0	7.7	60.7
Initial density of the rotifer				
0.05/cc	14.0	172.8	8.1	67.5
0.1	13.4	173.2	7.7	64.6
	15.4	164.0	9.4	74.2
10	18.8	179.2	10.5	90.6
30	13.6	204.8	6.6	65.5

駒込ピペットで 5 cc をとり，固定後遠心分離器で沈澱させ計数盤に移して計数し，1 cc 中の耐久卵数を算出し，Table 3 に掲げた。

Br. plicatilis の耐久卵の形成量は，Table 3 に明かのように，餌料としての植物性プランクトン量に支配され，従つてこの輪虫の増殖と密接な関係が見られるが，出発点における輪虫の個体数密度には殆んど影響されない。培養液として藍藻類の*Merismopedia tenuissima* から成り，34.24×10^6 細胞/cc を含んだ養鰻池水を用いた場合には，耐久卵の形成量は大体，12.6～18.8 個/cc である。次にこの耐久卵数の最大個体数密度に対する割合(%)を見ると，Table 3 の第 4 列に示されているように，全体的に見ると，養鰻池水そのままを培養液とした場合には約 7～11% と見積ることが出来る。この耐久卵は厚膜を有して重く，遊離又は母被甲の内部に入つたままで器底に沈積している。いま三角フラスコの器底面上における耐久卵の分布密度を計算して見る。200 cc 容量の三角フラスコの底面積を 33.2 cm^2，水量を 160 cc とし，底面に一様に分布していると見做すと，底面 1 cm^2 あたりの耐久卵の分布密度は，Table 3 の最後の列に示したように，60.7～90.6 個/cm^2 となる。実際の養鰻池においては水深が大きい (約 80～100 cm) ので，本実験と同様の割合で形成されたとしても，1 回の *Br. plicatilis* の大増殖だけで，底泥上の耐久卵の分布密度はこの実験結果の 16～20 倍位になると考えられる。実際の養鰻池の池替前後に調査した底泥上における耐久卵の分布密度の観測結果は別報に報告する予定である。

摘 要

1) 本実験は汽水性輪虫類の *Brachionus plicatilis* O. F. Müller の増殖に対する餌料としてのプランクトン植物量及び出発点における輪虫の個体数密度の影響並に耐久卵の形成量を明かにするために行つたものである。

2) *Br. plicatilis* の増殖速度並に増殖量は餌料としてのプランクトン植物量の多い程大きく，また飽和密度に達してからの斃死速度も大きい。

3) *Br. plicatilis* の最大個体数密度 (個体/cc, X) とプランクトン植物量(細胞/cc, Y) との間には Fig. 2 に示したような指数関係，$Y=aX^b$ が適用され，この場合，$a=20071$, $b=1.452$ であつた。

4) 従つて 2)，3) から，餌料としてのプランクトン植物量の多い池程，*Br. plicatilis* の増殖速度・増殖量は大きく，従つて水変りの速度・変化量も大きく，水変りの程度も大きくなる可能性がある。

5) *Br. plicatilis* の増殖に対する出発点の個体数密度の影響は著しく明瞭ではないが，全体的に見ると，個体数密度の大きいものが，増殖速度は早く，最大個体数密度に到達する時間は短い。しかし飽和密度の高さは餌料としてのプランクトン植物量が同一であれば略々等しい。

6) 増殖時における *Br. plicatilis* の耐久卵の形成作用は顕著であり，その形成量はプランクトン植物量が 34.24×10^6 細胞/cc 程度で，藍藻類の *Merismopedia tenuissima* を主とした養鰻池水の場合には，12.6～18.8/cc で，最大個体数密度に対する形成率は約 7～11% で，器底 1 cm^2 あたりの分布密度は約 61～91 個となる。

文 献

1) 伊藤 隆: Rept. Fac. Fish., Pref. Univ. Mie, 2, (1), 162-167 (1955).
2) ————: Ibid., 2, (1), 168～177 (1955).
3) 伊藤 隆・岩井寿夫: Ibid., 2, (2), 335～346 (1956).

Report of Faculty of Fisheries,
Prefectual University of Mie,
Vol. 2, No. 3. July 30, 1957.

養鰻池の水変りに関する研究

VII. Brachionus plicatilis の捕食作用とプランクトン植物の大きさ*

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Studies on the "Mizukawari" in Eel-culture Ponds

VII. The Relation between the Feeding Habit of Brachionus plicatilis and Size of Phytoplankters

(*With 3 Text-figures and 1 Table*)

TAKASHI ITO and TOSHIO IWAI

Résumé

1) From the laboratory observations, indirectly in the change of the "size-composition" of photoplankters as the food source through the feeding of a brackish-water rotifer, *Brachionus plicatilis* O. F. MÜLLER, and directly in the feeding habit of the rotifer, the possible size for the feeding of *Br. plicatilis* has been inferred to be under 12–15 μ. (Figs. 1–3).

2) The important part played by *Microcystis* (blue-green algae, macro-phytoplankton) as a control of the "Mizukawari" caused by the rotifers in the eel-culture ponds has been discussed.

養鰻池における"水変り"の有力な1要因である汽水性輪虫類, *Brachionus plicatilis* O. F. MÜLLER の餌料としてのプランクトン植物の大きさにはある限界が存在し，その捕食可能限界は大体 10~12 μ 以下であろうことは第5報[1]に簡単に報告した。養鰻池における *Br. plicatilis* による"水変り"の速度と程度は，輪虫の捕食可能なプランクトン植物量と不可能な植物量との割合，換言すると植物性プランクトンの"Size-composition"に大きく支配されるのではないかと考えられる。本研究はその基礎実験として，*Br. plicatilis* の捕食作用に伴う植物性プランクトンの大きさの組成の変化から間接的に，且つ顕微鏡下にその捕食作用を直接に観察し，*Br. plicatilis* のプランクトン植物の捕食可能限界を明かにするために行つたものである。本研究にあたり種々の助言を与えられた本学水産学部長岡田弥一郎教授，並にプランクトン植物の同定に関し御教示戴いた本学部浮游生物学教室故赤塚孝三講師に深甚の謝意を表します。尚本研究は昭和30年度文部省科学研究助成金によつたものである。

材料並に方法

1. 培養液としての池水と植物性プランクトン： 津市島崎町黒宮養魚場第2号養鰻池から昭和30年10月12日（透明度 16 cm; W.T. 17.8°C; Cl 3.55‰）に採水し，プラ

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* 本報告の大要は昭和31年4月日本水産学会年会で発表した。

ンクトンネットで濾過し動物性プランクトンを取除いた池水そのままを実験に供した。この池水中のプランクトン植物の種類と各種の細胞数は次の通りである。

Cyanophyceae	
Merismopedia tenuissima	22.938×10^6 cells/cc
Synechococcus sp.	0.750
Microcystis sp.	0.470
Chlorophyceae	
Selenastrum sp.	1.030
Dictyospherium pulchellum	0.064
Scenedesmus spp.	tr.
Chrocooccus sp.	0.251
Diatomaceae	
Cyclotella glomerata	0.125
Navicula spp.	0.436
Nitzschia closterium	tr.
Total	26.064×10^6 cells/cc

全体的には藍藻類が卓越し，特に *Merismopedia tenuissima* が全細胞数の 88% を占め優占種になつている。実験には 2 種の池水を用いた。第 1 はこの緑色池水そのまま，第2はこの池水をそれと同塩分の稀釈海水で 2 倍に稀釈した。前者を"第 1 水槽"，後者を"第 2 水槽"と呼ぶことにする。

2. 輪虫の材料: 津市栗真町屋町加藤養魚場第 2 号養鰻池から 10 月 12 日(昭 30) (第 5 次水変りの末期; 透明度 59 cm; W.T. 16.9°C; Cl 3.84‰) に採集した *Br. plicatilis* を 1 日間放置して後実験に供した。

3. 実験方法: "第 1 水槽" 並に "第 2 水槽" の各 5 L (大型角水槽) に上記の *Br. plicatilis* を池水 1 cc について 10 個体の割合に加えた。また池水そのままに輪虫を加えないものを Control として，3 水槽を直射日光のあたらない南窓側におき，各水槽中の植物性プランクトンの大きさの組成の変化を 2 週間に亘つて追跡し，*Br. plicatilis* の捕食作用による植物性プランクトンの "Size-composition" の変化からその捕食限界を間接的に推定することを試みた。植物性プランクトン並に *Br. plicatilis* のサンプリングは各水槽をよく撹拌しながら駒込ピペットによつて所定量を抽出した。植物性プランクトンは各 2 cc を取り，第 1 水槽並に Control のはそのまま，第 2 水槽のは遠心分離器 (2000 回/分，15 分) によつて 1/4 に濃縮し，血球計算盤により小区劃 200~300 区劃中に出現するプランクトン植物の大きさを群体を単位として，micrometer によつてその長径並に短径を測定及び計数し，その短径によつて池水 1 cc 中の群体数で表現した。*Br. plicatilis* は駒込ピペットで中層から 10 cc を抽出し，固定後遠心分離器にかけて沈澱させ，個体数の少いときは全部を，多い場合にはその 1/2~1/4 をとつて計数盤に入れて生存個体数を計数し，池水 1 cc あたりの個体数を算出した。

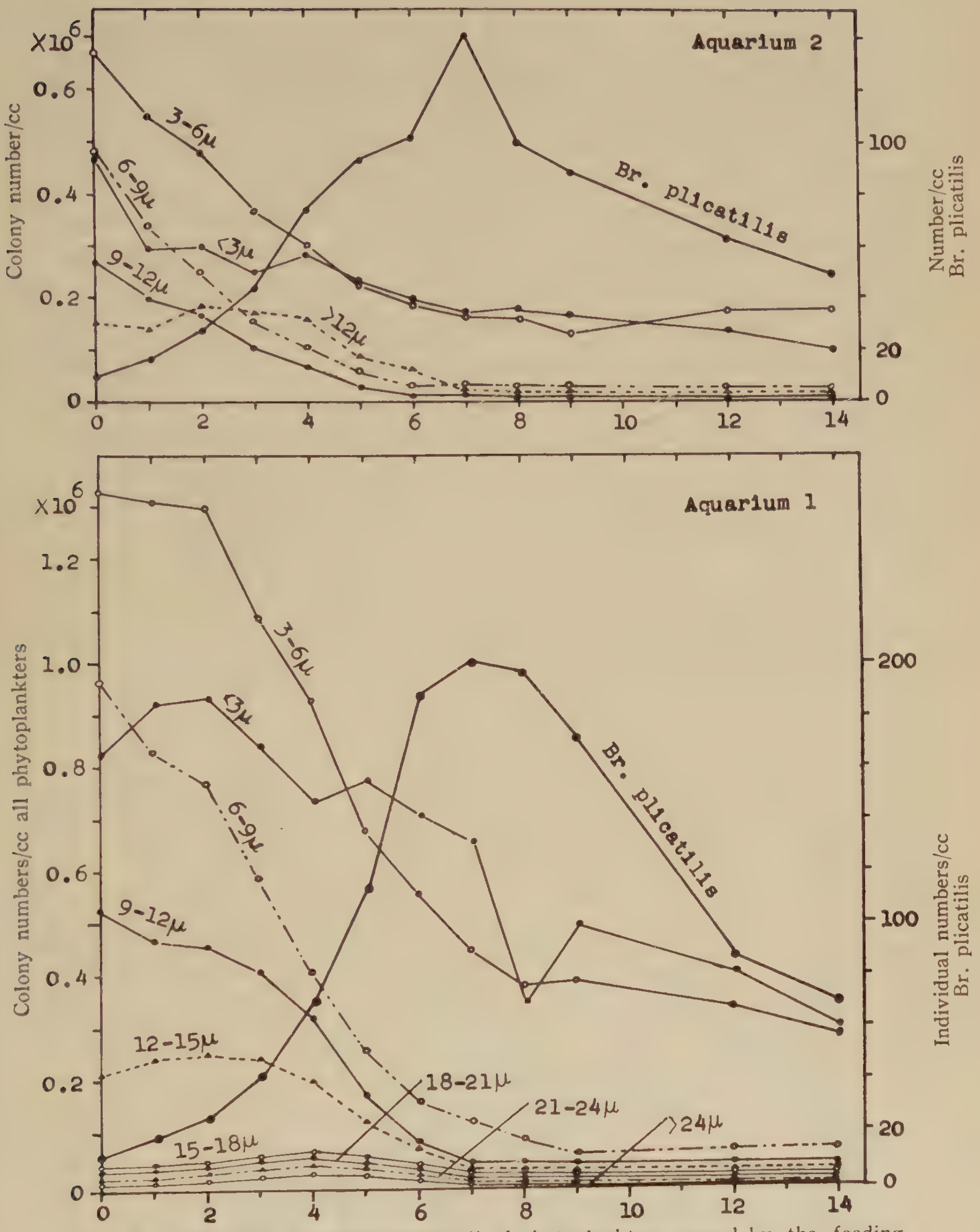


Fig. 1. Changes in "size-composition" of phytoplankters caused by the feeding of *Branchionus plicatilis*.

Aquarium 1: contains 34.24×10^3 cells of all phytoplankters per cc at the starting point.

Aquarium 2: contains a half of phytoplankters in aquarium 1.

Br. plicatilis was inoculated each media at the rate of 10 individuals per cc.

実験結果

1. 間接的方法: プランクトン植物の大きさの組成の変化

Brachionus plicatilis の捕食作用による植物性プランクトンの大きさの組成の測定結果には相当大きい変動があつたので，その傾向性を知るために 3 つ宛の移動平均を求めて Figs. 1~2 に示した。

"第1水槽" においては，最初 10 個体/cc の割合に加えた *Br. plicatilis* はその後大増殖を示し，6~8 日後に略々飽和密度になり 202 個体/cc に達した。9 日後から急激に死滅が始まつた。植物性プランクトン量は細胞数の点から見ると，4日後までは殆んど変化はないが，*Br. plicatilis* の大増殖とは逆に，5 日後から急激に減少し，8 日後には実験前の 1/58 に減少した。次に輪虫の捕食作用による植物性プランクトンの大きさの組成の変化は Fig. 1 下段に明かのように，その減少速度は 3~6 μ, 6~9 μ に属するものが最も大きく，3 μ 以下並に 9~12 μ のものがこれに次いでいる。12~15 μ のものは最初の

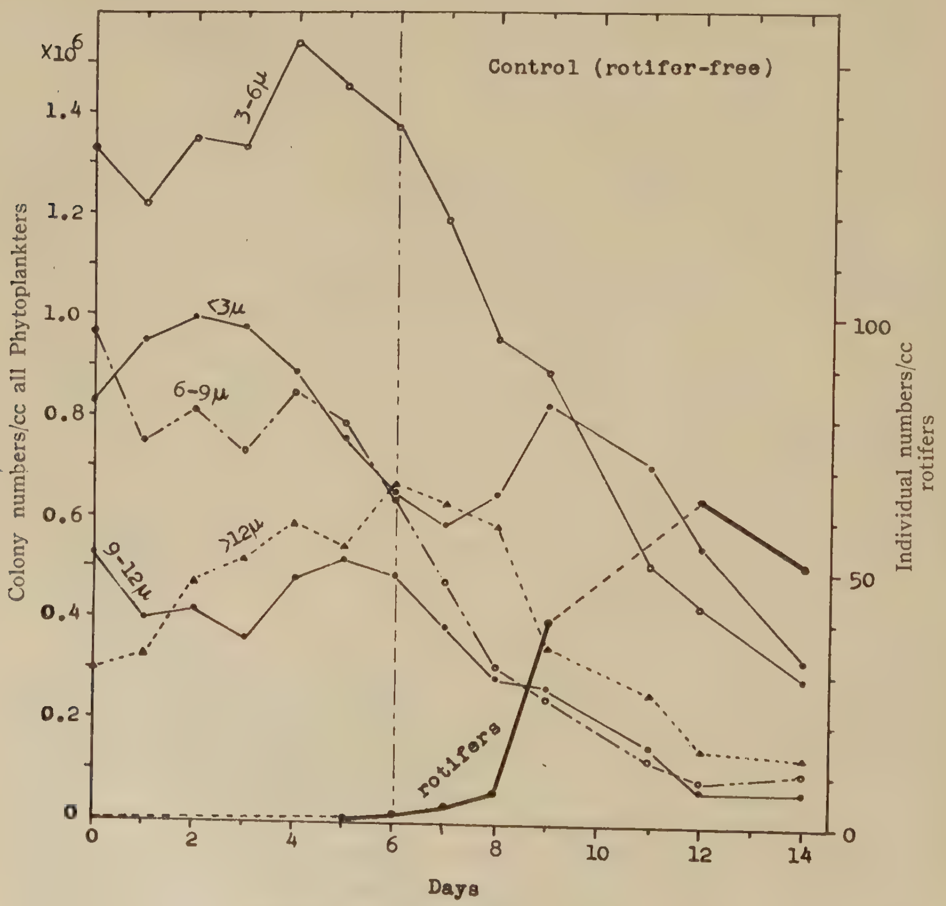
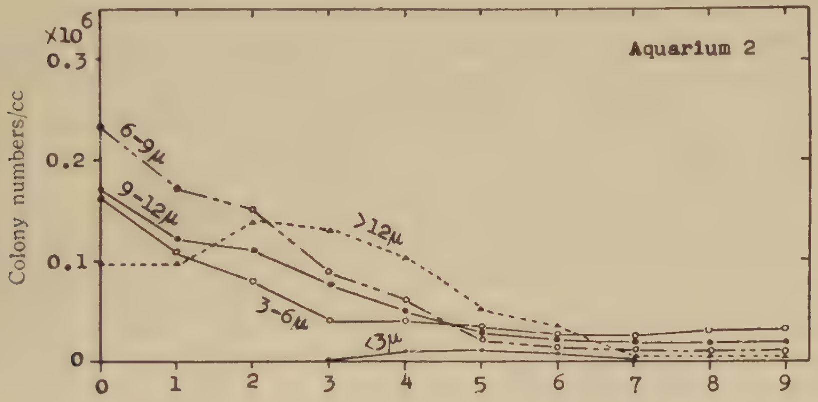


Fig. 2. Control (rotifer-free) Phytoplankters suddenly decrease 5-6 days after, it will be caused by the feeding of other rotifers, *Br. urceolaris* and *Br. quadridentatus*, which is unexpectedly grew at the same times.

4 日間位は殆んど減少しないが，5~6 日後の *Br. plicatilis* の大増殖時に稍々減少する。しかし 15 μ 以上のものは量的にも少いが，殆んど減少しない。3 μ 以下~12 μ の小型のプランクトン植物の減少によつて，培養液は著しく透明度を増し，大型のプランクトン植物が水中に顕著に目立つてくる。これらの大型群は 6~8 日後から緑色を減じ，黄褐色を帯び，器底に沈積する傾向になる。

"第 2 水槽" 並に第 1 水槽の植物性プランクトンの優占種である *Merismopedia tenuissima* についても上述の傾向と全く同じ結果が得られた。(Fig. 1 上段; Fig. 3)。従つてこの間接的な観察結果から，*Br. plicatilis* によるプランクトン植物の捕食可能限



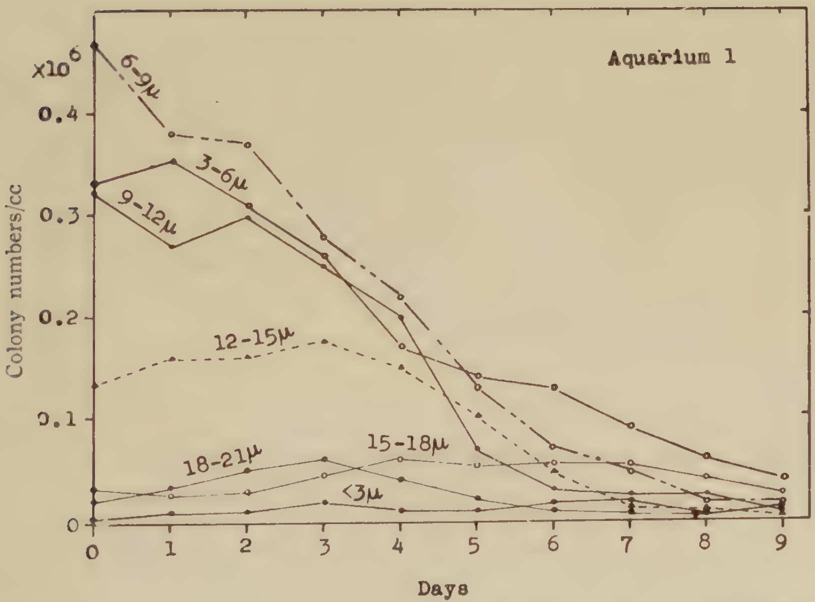


Fig. 3. Changes in "size-composition" of *Merismopedia tenuissima*, dominant species in the media by the feeding of *Br. plicatilis*.

Aquarium 1: green pond water.

Aquarium 2: green pond water diluted a half with isotonic sea water.

界は 12～15 μ 以下であると推定される。

Br. plicatilis を加えない "Control 水槽" では，6日後までは植物性プランクトンの細胞数もまた大きさの組成も殆んど変化しない。しかし7日後から急激に減少をはじめ，12日後には実験前の細胞数の 1/20 に減少した。またプランクトン植物の大きさの組成の変化も第1水槽と同様な傾向を示した。これは他の淡水産輪虫類に属する *Br. urceolaris*, *Br. quadridentatus* の大増殖期に一致しているので，おそらくこれらの輪虫類の捕食作用によることは明かであろう。Control に *Br. urceolaris* が大増殖を示し，植物性プランクトンが急減し，溶存酸素・pH・水色・透明度等が *Br. plicatilis* による"水変り"と同様になつた例は第2報[2]に既に報告した。従つて本実験においても Control の意味が半減したが，しかし，*Br. plicatilis* のみでなく *Br. urceolaris* 並に *Br. quadridentatus* の大増殖とその捕食作用によつても "水変り" が生起する可能性があり，且つそれらのプランクトン植物の捕食限界の大きさは，*Br. plicatilis* と同様 12～15 μ 以下であろうことを明かにすることの出来た点は更に意義があるといえよう。

2. 直接的観察

前記の水変り養鰻池から採集し，高い個体数密度で実験室に放置し，飢餓状態においた *Br. plicatilis* を用いて，そのプランクトン植物の捕食作用を顕微鏡下に直接的に観察した。この輪虫の 30～50 個体をホローグラスにとり，それに前述の *Merismopedia* 池水を少量注入した。輪虫は輪盤の繊毛運動により水流をおこし，その水流中の植物性の Nannoplanktonを盛んに摂取する。その捕食作用は驚くべきものであり，飢餓状態の透明な消化管は見る間に新鮮な藻類によつて緑色に変る。スライドの底部に脚で附着し，体をカバーグラスに垂直にし摂餌中の個体について，口径を測定したところでは，被甲長 160～210 μ の ♀♀ では口径は 25～37 μ で，多くの繊毛を以て囲まれている。その捕食するプランクトン植物の大きさについて根気強く観察し，直径 19 μ の *Microcystis* sp.，並に 32 細胞 (19×10 μ) の *Merismopedia tenuissima* の群体を摂取したが直ぐ吐き出した。しかし直径 20 μ の *Chroococcus* sp. の群体は摂取されなかつた。盛んに摂餌するのはすべてこれらより小型のものであることが観察された。この簡単な直接的観察の結果は，プランクトン植物の大きさの組成の変化の間接的結果と略々一致している。従つて*Br. plicatilis* の捕食可能なプランクトン植物の大きさは，被甲長 160～210 μ の個体では大体 12～15 μ 以下のものであると推定出来よう。餌料の選択性は捕食限界内の植物性プランクトンでは見られないようである。

考　　察

養鰻池における Microcystis (藻藍類) の重要性について

藍藻類に属する *Microcystis* は塩分含有量の少い養鰻池に多量に増殖し，最も重要なプランクトン植物の1つである。*Microcystis* は群体を形成し，その形状並に大きさは区々であり，118～78 μ 位は普通で大きいものは 627～314 μ に達する。これらは青緑色の大粒の粉を水中にばらまいた様に見えるので一般にアオコ(青粉) と呼ばれている。*Microcystis* の群体は一般に大きく輪虫類による捕食は不可能であり，輪虫の異常増殖した水変り池では両者が共存している。このような池では共存した *Mycrocystis* の光合成

によつて酸素が供給されるので，輪虫が相当に増殖しても池水の pH 並に溶存酸素等もそれ程低下せず，この *Microcystis* によつて水変りの速度は抵抗を受け，余り大きい水変りにならないことは第 4 報[3]で述べた。この水変り池から *Microcystis* 並に *Br. plicatilis* をプランクトンネットでその池水中に濃縮し実験室に持参し，角水槽に 3L を入れ，*Br. plicatilis* 並に *Microcystis* の個体数並に群体数の変化を調べて見た。*Br. plicatilis* は 1 日後には 3260 個体/cc，2 日後には 868 個体/cc，3 日後には 55 個体/ccに減少し，5～7日後には全く死滅した。これに対し池水中の *Microcystis* 以外の Micron-algae は 1～2 日の中に食い潰され，池水は透明になり，その中に *Microcsystis* の大粒子の散在を透視出来るようになつた。しかし *Microcystis* の群体数は 1 日後には 2150/cc，2 日後には 2644/cc，3 日後には 2450/cc で殆んど変化せず，この状態が *Br. plicatilis* の死滅後まで見られた。この実験から *Br. plicatilis* の *Mycrocystis* の捕食は不可能であり，且つ *Microcystis* は輪虫の大増殖した異常水質に対しても強い抵抗性があることが分る。これらの点から見て *Microcystis* は輪虫類による養鰻池の水変りを制御する重要な特性を有し，養鰻池における植物性プランクトンとして重要な位置にあるといえよう。

伊藤(未発表資料)によつて，伊勢湾西岸の伊曽島から穴川に至る 185 の養鰻池の中，透明度 30 cm 以下で，植物性プランクトンがよく繁殖し植物色を呈し，水変りしていない 137 面の養鰻池について，*Microcystis* とそれ以外の micron-algae の増殖状態を肉眼的に観察した結果を，池水の塩素含有量との関係で分類して Table 1 に示した。

Table 1. The relation between the production of *Microcysti*; ("Aoko") and the chlorine contents of eel-culture ponds on the west coast of Ise Bay, Mie Prefecture. The figure in the table shows the number of ponds.

Chlorine contents of pond water Cl ‰	*Microcystis* (="Aoko")					Other micron-algae
	Very Abundant	Abundant	Common	Rare	Very rare	
0.1～1.0	5	10	3			
1.0～2.0	2	7	15	11	3	5
2.0～3.0	3	6	5	3	1	13
3.0～4.0			1	2	3	9
4.0～5.0			2	1	1	5
5.0～6.0				1	1	3
6.0～7.0						8
7.0～8.0						8
Total	10	23	26	18	9	51

Microcystis の増殖程度は池水の塩分と密接な関係があり，著しいアオコの見られるのは大体 Cl 3‰ 以下の池であり，それ以上の池ではアオコの増殖は悪くなり，Cl 5‰ 以上の池には *Microcystis* は殆んど見られず，植物性プランクトンは *Microcystis* 以外の極めて小型の所謂，nannoplankton に属する micron-algae が卓越している。三重県の養鰻池における水変りの程度を見ると，池水の塩分の小さい北勢地方(城南・川越・楠)並に香良州，松阪地区では大きい水変りは殆んど見られない。これに対し塩分の濃い津，

穴川地区に第一級の水変りがしばしばおこり，大量の斃死魚を出し，且つ池水に安定性のないのは，輪虫類の捕食可能限界以下の微小な植物性プランクトンの或る限られた少数の種類のみが卓越していることが 1 因をなしていると思われる。従つて輪虫類の捕食可能な小型のプランクトン植物と捕食されない *Microcystis* 等の大型群との混合割合，小型プランクトン植物量，並に大型プランクトン植物の水変り環境に対する抵抗性の強弱等が輪虫類による水変りの程度に差異を生ずる要因になるのではないかと考える。これらの点は更に将来の研究によつて解決さるべき問題であろう。

摘　　要

1)　本研究は汽水性輪虫類の *Brachionus plicatilis* の植物性プランクトンの捕食作用による“水変り”の基礎問題として，この輪虫の捕食可能なプランクトン植物の大きさの限界を明かにする目的で行われた。

2)　食餌源としての植物性プランクトンの大きさの組成の変化と，その捕食作用の直接的観察の 2 方法から，*Brachionus plicatilis*, *Br. urceolaris* 並に *Br. quadridentatus* 等の輪虫類のプランクトン植物の捕食限界はおよそ 12～15 μ 以下であることが推定された。

3)　養鰻池における輪虫類による“水変り”の制御に対する大型植物性プランクトンに属する *Microcystis* (アオコ)の重要性と“水変り”の程度の 1 要因としての植物性プランクトンの大きさの組成が考察された。

文　　献

1)　伊藤　隆・岩井寿夫：Rept. Fac. Fish., Pref. Univ. Mie, 2, (2), 335～346 (1956).
2)　伊藤　隆：Ibid., 2, (1), 168～177 (1955).
3)　伊藤　隆・岩井寿夫：Ibid., 2, (2), 325～334 (1956).

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Prefectural University of Mie,
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ヒロメの発生に関する研究—I

配偶体の発生とそれに及ぼす光線の強さの影響について

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Studies on the Development of Undaria undarioides (YENDO) OKAMURA (I)

On the Development of Gametophytes and Influence of Light Intensity on it

(*With 2 Plates and 6 Text-figures*)

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Résumé

1. Since 1955 the writers have been studying on the development of gametophytes of *Undaria undarioides* (YENDO) OKAMURA which shows rather peculiar distribution in Japan and on the influence of light intensity on it. The present paper deals with this study. The gametophytes were cultured in the laboratory of their University under different light intensities as follows :

a) In full sunlight through a window glass, avoiding the direct rays. (about 4500 lux).
b) Covered with one thin white and semi-transparent vinyl cloth. (about 3200 lux).
c) Covered with one thick, white and semi-transparent vinyl cloth. (about 2200 lux).
d) Covered with one thin, grey and semi-transparent vinyl cloth. (about 1000 lux).
e) Covered with one thick, grey and semi-transparent vinyl cloth. (about 400 lux).
f) In total darkroom. (0 lux).

(~lux) : Shows light intensity in the fine daytime. The materials used in this examination were collected by them at Goza Head, Shima Peninsula, March—April, 1955-1957.

2. Kanda (1936) has reported on the development of gametophytes of *Undaria pinnatifida* SURINGAR. According to a culture of zoospores of *Undaria undarioides* (YENDO) OKAMURA the writers made, they came to the same conclusions as those obtained in his study so far as the process of development is concerned. Before the male and female gemetophytes came to maturity, however, there took place cell-divisions of several female gametophytes along the longitudinal walls, and then parthenogenetical development of them was also observed. The writers expect to make a report on the process of development of sporophyte in the near future.

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3. In decreased lights (about 3200–2200 lux), gametophytes grew faster than in the full sunlight through a window glass (about 4500 lux). In more decreased lights (below about 2200 lux), the development becomes later proportionately as the light decreases in lux. In the dark light (about 400 lux) they did more slowly germinate. In a totally dark room they did germinate normally, but at the slowest speed. Furthermore, these individuals died out sooner than others. The survival rate both in the full sunlight and darkroom was falling. In other cases, the rate becomes lower in proportion to the increase of lux of the light and that of temperature of the water.

In general, the results obtained in this study came to the same conclusion as Arasaki (1953) and Saitō (1956) have reported on those of *Undaria pinnatifida* SURINGAR etc.

緒　　言

ヒロメ *Undaria undarioides* (YENDO) OKAMURA (Plate XXXIV, 1) は本邦特産のワカメ属に属し，ワカメと同様に食用にされるが，分布は狭く，主として紀伊東岸，志摩半島南岸，房州船形などに産するのみである。生育場所としてはワカメ *Undaria pinnatifida* (HARV.) SURINGAR よりも更に黒潮の影響の強い様な所の水深 1 乃至数尋程度の岩礁などであるが，志摩半島片田，布施田附近など，ワカメ及びヒロメの分布の境界となる場所では両種の中間形（俗称，ヤナギメ）を産する。即ち，茎は比較的長く成実葉が相当発達して中肋の狭いもの，又，葉の縁辺の片側或は両側が比較的深く羽状に弯入しているものなど形態は色々であるが，一見，何れとも区別し難いものも見られる。子嚢群は栄養葉の基部一面に形成され，この地方での游走子の成熟期は大体 2 月下旬頃から 5 月上旬頃で，2 月から 4 月にかけて繁茂する。

従来，ヒロメの発生及び生態等に関しては著者等が 1953 年秋水産学会大会で，その配偶体の発生について発表を行つた外は全く報告されていないが，他のコンブ科植物，特に本邦諸沿岸に広く分布する同属のワカメについては発生，生態及び増殖の基礎問題，実際の養殖法など色々の角度から詳細な研究が進められている。即ち，本報告に関連したその主なものとして，コンブ科植物の配偶体については井狩 (1921)，三宅 (1928)，神田 (1933–43)，木下 (1947)，SAUVAGEAU (1915)，KYLIN (1916–18)，WILLIAMS (1921)，PRINTZ (1922)，SCHREIBER (1930) 等の報告があり，SCHREIBER 等は単為発生及び各種の交配などについても報じている。又，生態に関しては殖田(1929)，木下(1947)，新崎(1953)，斎藤 (1956)，SCHREIBER (1930)，HARRIES (1932) 等の研究があり，最近，斎藤がワカメの配偶体，芽胞体についてその生態的諸要因を報告している。

本報告は志摩半島産のヒロメについて，配偶体の発生とそれに及ぼす光線の強さの影響を観察実験し，2，3 の知見を得たので，これまでの結果を報告したものである。

材料及び方法

材料は志摩半島御座岬に於いて 1955 年以来毎年 3～4 月に採取した。採取された材料は実験室に持帰つてから数時間陰干しを行い，十分成熟した葉体の基部を適当の大きさに切り，生育地の海水を脱脂綿で濾過した培養海水を用い，大型バットの中に浸し，スライドガラス，カキ，トコブシなどの貝殻を敷いて放出された游走子が付着する様にした。数時間後，海水が幾分黄濁し，游走子の放出が見られた。放出時の水温は 11.0°C～

16.0°C の間で色々行つて見たが何れもよく放出した。しかし材料は採取後 2 日以上経過すると殆んど游走子を放出しなくなる様で，出来るだけ早く処置した方が好結果が得られる。游走子がスライドガラス及び貝殻に適当に付着した頃取揚げ，別の培養器に移して，直射日光を避け，培養液は約 10 日に一度，1/2 量ずつ新しい液と換えて培養し，Schreiber solution を添加して発生を促した。游走子の鞭毛はヨードヨードカリ液で染色して観察した。尚，培養中の水温が 11.0°C→20.0°C の場合と 15.0°C→24.0°C の場合では発生速度が後者の方が早かつたが斃死率も高く，24.0°C 前後では配偶体の成熟も見られなかつた。

又，一方，配偶体の発生に及ぼす光線の強さの影響を調べるために次の如く異つた光の強さの下に培養して実験を行つた。

a) 直射日光を避け，窓ガラスを通した天然光，(約 4500 lux)
b) 白色半透明の薄いビニール 1 枚でカバーした明るさ (約 3200 lux)
c) 白色半透明の厚いビニール 1 枚でカバーした明るさ (約 2200 lux)
d) 灰色半透明の薄いビニール 1 枚でカバーした明るさ (約 1000 lux)
e) 灰色半透明の厚いビニール 1 枚でカバーした明るさ (約 400 lux)
f) 全く暗い暗室の中 (0 lux)

観察及び実験結果

1. 配偶体の発生

a) 游走子とその発芽

放出された游走子 (Fig. 1, A–D, Plate XXXIV, 2) は平均長さ 7 乃至 8 μ, 幅 5 乃至 6 μ の西洋梨形で体の側面に長短 2 本の鞭毛を有し，前方の長い方を活溌に動かして游泳しているが眼点は見られず趨光性も示さない。鞭毛の長さは長い方が 15 μ 前後で前方に伸び短い方は 9 μ 前後で後方に伸びている。体の前方の尖つた部分には色素体が殆んどなく後方楕円の部分に数個の顆粒物質が色素体及び核と共に集つている。游走子は放出後数時間游泳して後，スライドガラス，貝殻の上に沈着し静止して鞭毛を失い，間もなく直径 6 乃至 7 μ の球形細胞即ち胚胞子 (Embryospore) となる (Fig. 1, E–G, Plate XXXIV, 3)。更に数時間経過すると胚胞子の一部が膨出し始め発芽管を出して来る(Fig. 1, H–L, Plate XXXIV, 4)。約 24 時間の後，管が伸長するにつれて原細胞の内容はその先端の膨んだ部分へ移つて行くが，(Fig. 1, O–S) 中には発芽管が或程度伸長してしまつてから始めて内容の移行が行われるものもある (Fig. 1, M, N)。2·3 日経過すると管の長さは 25 μ 前後となり，内容物が管の先端に殆んど移つてしまい，その部分が膨大し始める (Fig. 2, A–E, Plate XXXIV, 5)。そして 4 日目に管と新細胞間に隔壁が見られる様になるが，その後は新細胞内の色素体の数も増し，次第に日数の経過と共に大きさも増して来る (Fig. 2, F–N, Plate XXXIV, 6)。しかし，稀には隔壁が出来ても原細胞にその内容の一部が残つているものもある。

b) 雌性及び雄性配偶体

8 日培養のもので始めて細胞分裂が見られ，2 細胞となつた (Fig. 2, O–R)。その頃からこれらの配偶体に雌雄の別が大体認められる様になり雌性配偶体は大部分細長く数個以上の細胞から成り不規則な枝分れして分岐体となる (Fig. 2, S, T, X, Y, Fig. 3,

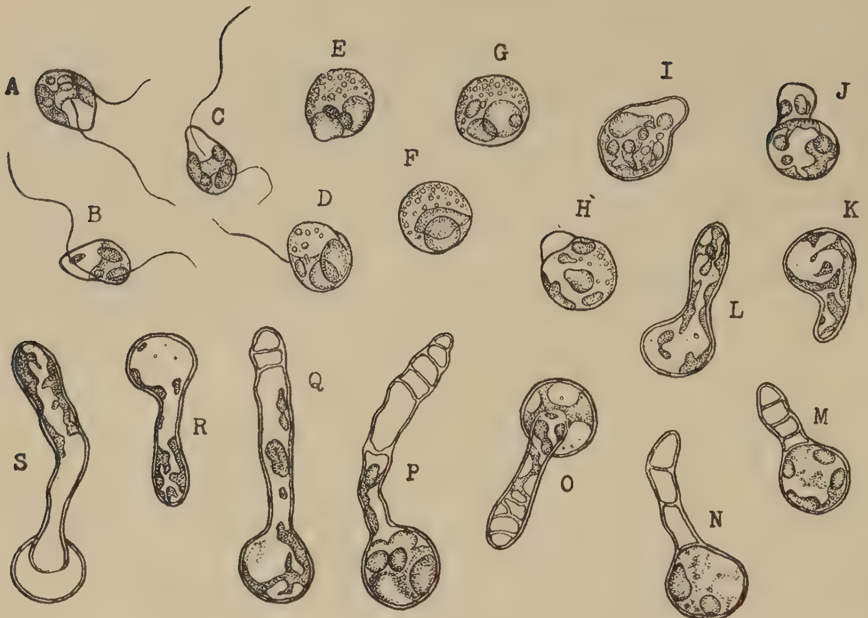


Fig. 1. *Undaria undarioides* (YENDO) OKAMURA.
Zoospores and their germination (1). ×1730.

A–D. Zoospores in motile state.
E–G. Embryospores from a culture 5–6 hours old.
H–N. Germination of the embryospore in a culture 15 hours old.
O–S. From a culture 24 hours old.

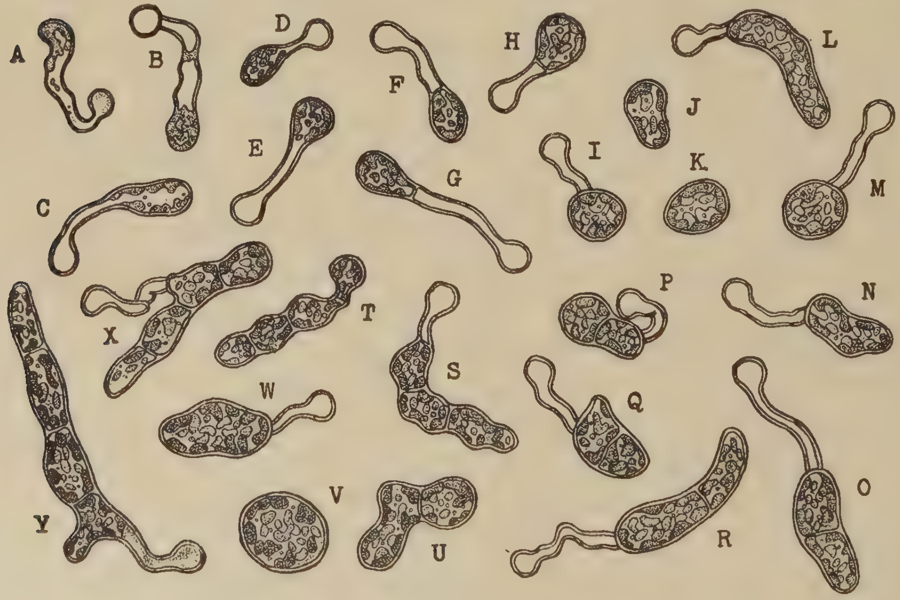


Fig. 2. *Undaria undarioides* (YENDO) OKAMURA.
Zoospores and their germination (2). ×690.

A–E. Sporlings from a culture 2–3 days old.
F–I. Sporlings from a culture 4 days old; the first cross wall is formed.
J–N. Sporlings from a culture 5–6 days old.
O–R. The first cell division takes place at this stage. From a culture 8 days old.
S–Y. Gametophytes from a culture 10–13 days old.

A–H, Plate XXXIV, 7, 9–11, 13)。細胞の直径は比較的個体差が大きいが約7乃至9μ位である。一方，雌性配偶体は殆んどが 1 個乃至数個の細胞から成り，細胞の直径が 10 乃至 15μ 程度であるが，(Fig. 2, U–W, Fig. 3, I–N, Plate XXXIV, 8, 12, 14) 稀には判別し難いものもある。又，原細胞に内容の一部が残されたまま発生して来たものでは原細胞の部分も色素体を増して膨大し，細胞分裂を行つて成長するのが見られる (Plate XXXIV, 9, 10)。10 日目から 30 日目位まではこの様な成長を続け，35日目頃から漸く成熟し始めて雄の方はあちこちの細胞から枝状に突出したり細胞の塊が出来，又，枝端の細胞などが色素体の色を失い内容全体が一様に淡青色となつて成熟し，(Fig. 4, A–F, Fig. 5, A, Plate XXXV, 1, 2) やがてその部分が蔵精器となり，1 個の精虫となる。38日の培養で蔵精器の先端の膜が破れて精虫が外に游出したが (Fig. 5, B, C, Plate XXXV, 3) これは長さ約 5 乃至 6μ，幅 3 乃至 4μ の蕎麦子に似た形をしており，2 本の鞭毛を有し，幾分長い前方のを盛んに動かして泳ぐ，数個の顆粒の他色素体は極く稀にしかなく，眼点もない (Fig. 5, D)。精虫の出た後の蔵精器は嘴状に開口して残つている。雌性配偶体は一般に数個以下の細胞からなり，大きさには大小色々あるが，稀には直径 20μ 以上に達するのもある。(Fig. 3, K–M, Fig. 6, F–J, Plate XXXV, 5, 6)。大抵は 3 乃至数個の細胞からなる場合が多くその中の 1 個或はそれ以上の細胞が蔵卵器となる。成熟すると蔵卵器の細胞は伸長し，色素体は細かくなり，先端の部分に集まりその部分に膨圧を感ずる如く観察される (Fig. 6, I, K)。

受精及び芽胞体の発生に関しては後日報告する予定である。

Fig. 3. *Undaria undarioides* (YENDO) OKAMURA.
Male and female Gametophytes. ×690.

A–D. Male gemetophytes from a culture 15 days old.
E–H. Male gametophytes from a culture 20 days old.
I–K. Female gametophytes from a culture 15 days old.
L–N. Female gemetophytes from a culture 20 days old.

Table 1. The development of gametophyte in different light intensity.
(Water temperature 15.0°C→24.0°C)

Date	IV-14 (1956)																					
			IV-19					IV-24				IV-29				V-4		V-9			V-14	V19
Days passed / Light intensity	1	4	5	6	7	8	9	10	11	12	14	15	17	18	19	20	21	25	26	29	30	35
a) about 4500 lux	germinate		transvers wall			2-cells			3-cells			5~6 cells					10~15 cells					survival rate (60%)
b) 〃 3200 〃	germinate	trans-verse wall			2-cells		3-cells			5~6 cells					10~15 cells							survival rate (80%)
c) 〃 2200 〃	germinate		transverse wall			2 cells		3-cells			5~6 cells					10~15 cells						survival rate (90%)
d) 〃 1000 〃	germinate			trasverse wall			2-cells			3-cells				5~6 cells					10~15 cell			survival rate (95%)
e) 〃 400 〃	germinate				transverse wall			2-cells					3-cells							5~6 cells		survival rate (95%)
f) 〃 0 〃			germinate (40%)																			survival rate (30%)

Number of cells: showing the cells of male gametophytes.

が前者の場合は全般的に発生が遅いが，光の強さによる発生速度の差異が比較的少い，又，生残率は高く，雌雄配偶体の成熟も見られたが，後者では特に天然光下と暗室での斃死率が高く，天然光下に於ける配偶体は高温のためか不規則な発生分岐体となり，多くの場合，皮層などの細胞は色素体が少なかつたり，或は褪色崩壊していたりして，細長く伸長しているもの多く，中には又数珠状に細胞が丸くなり，細胞間のくびれが深まつて，幾日経過しても殆んど変化がなく，Resting stage の様な状態のものが多かつた。各光線の強さと配偶子の発生速度などとの関係は Table 1 に示す如くである。

総括及び考察

著者等はヒロメの配偶体発生を数回に亘つて培養観察したが，雌雄配偶体の成熟，造卵器・精子器など発生過程に於いては神田(1936)の報告しているワカメの配偶体発生の場合と比較して殆んど相違する点が認められず，特に記載すべき知見は得られなかつた。発生の速度及び配偶体の形態などの大きさその他多少の形態的な相違は色々の培養条件によつて異る場合が多いことはコンブ科の植物について多くの研究者が報じているところである。単為発生に関しては SCHREIBER (1930) が 2, 3 のコンブ科植物について報告しているが，著者等が貝殻及びスライドガラス上の配偶体について観察したものの発生形態及び発生の時期も未だ雌雄配偶体の成熟する以前であることなどから，雌の単為発生体であることは明らかであろうと考える。

配偶体の発生に及ぼす光線の強さの影響を調べた結果では，近年，アラメなど各種の海藻について有賀(1953)等，又，ワカメに関しては斎藤(1956)等が報じている実験結果と大体一致し，稍，弱光下の 3200～2200 lux 附近が天然光下よりも少しく発生が早く，天然光下がそれに次ぐが弱光の約 2000 lux 以下では暗くなる程発生が遅く，暗室の中でも正常な形態で発生する様であるが極度に遅く全く発芽しないものも相当認められる。そして色素体の色も薄い。斃死率は暗室のものと天然光下のものが最も高く，それ以外の処では水温の上昇と共に光線の強い処程高いことが認められた。又，高水温(15.0°C→24.0°C)の場合より低水温(11.0°C→20.0°C)の場合の方が，光線の強さによる発生速度の相違は少ない結果が得られた。

文　献

1) 有賀祐勝: 海藻胞子の発芽・生育に及ぼす光の影響に関する二,三の実験., 日水会誌 19 (4) 1953.

2) DELF, E. M. and LEVYN, M.: Reproduction in *Macrocystis pyrifera* AG., Ann. of Bot. 40. 1926.

3) HARRIES, R.: An investigation by cultural methods of some of the factors influencing the development of the gametophytes and early stages of the sporophytes of *Laminaria digitata*, *L. saccharina* and *L. cloustoni*., Ann. of Bot. 46. 1932.

4) IKARI, J.: Development of *Laminaria religiosa* MIYABE., Bot. Mag. Tokyo. 35. 1921

5) ――: On the culture of the swarmspores of *Ecklonia bicyclis* KJELLM., Jour. of Fish. 29. 1927.

6) 神田千代一: 二, 三の昆布科植物の配偶体に就いて(予報), 北大海藻研報. 1. 1933.

7) ――: 二, 三の昆布科植物の配偶体に就いて (二報), 北大海藻研報. 4. 1935.

8) ――: On the Gametophytes of Some Japanese Species of Laminariales. I–V., Sci. Pap. Ist. Alg. Res. Hokkaido Imp. Univ. 1–3. 1936–1944.

9) ―――: 暖海産昆布科植物の游走子培養に就いて., 服部研報. 8. 1939.
10) 木下虎一郎: コンブとワカメの増殖に関する研究., 北海道浅海水族の増殖に関する研究. 1. 北方出版社. 1947.
11) KYLIN, H.: Ueber den Generationswechsel bei *Laminaria digitata*., Svensk. Bot. Tidsskr. 10. 1916.
12) MIYAKE, K.: On the Sexual Generation of Japanese Laminariaceae., Proc. 3rd Pan. Pacific Congr. Tokyo. 2. 1922-23. 1928.
13) 岡村金太郎: わかめの生殖法., 植雑. 36. 1890.
14) ―――: *Undaria* and its Species., Bot. Mag. 29 (346) 1915.
15) ―――: 日本海藻誌., 1936.
16) OLTMANNS, F: Morphologie und Biologie der Algen. III. 1922.
17) PRINTZ, H.: Ueber den Generationswechsel bei den *Alaria* det norwegischen Westküste., Det. Kgl. Norske Vidensk. Selb. Skrif. Nr. 1. 1922.
18) 斎藤雄之助: ワカメの生態に関する研究. I. II 報., 日水会誌. 22 (4) 1956.
19) SCHREIBER, E.: Untersuchungen über Parthenogenesis, Geschlechtsbestimmung und Bastardierungsvermögen bei Laminarien., Planta. Bd. 12. 1930.
20) UEDA, S.: On the temperature in relation to the development of the Gametophyte of *L. religiosa* MIYABE., Jour. Imp. Fish Inst. Tokyo. 24 (5) 1929.
21) WILLIAMS, J. L.: The gametophytes and fertilization in *Laminaria and Chorda*., Ann. of Bot. 35. 1921.
22) 遠藤吉三郎: 海産植物学. 1913.

PLATES XXXIV—XXXV

Explanation of the Plate XXXIV

Undaria undarioides (YENDO) OKAMURA

1. Frond collected at Goza Head, Shima. ×1/5.
2. Zoospore in motile state. ×800.
3. Embryospore. ×800.
4. Germination of the embryospore in a culture 15∼24 hours old. ×800.
5. Sporlings from a culture 3 days old. ×500.
6. Sporlings from a culture 4 days old; the first cross wall is formed. ×500.

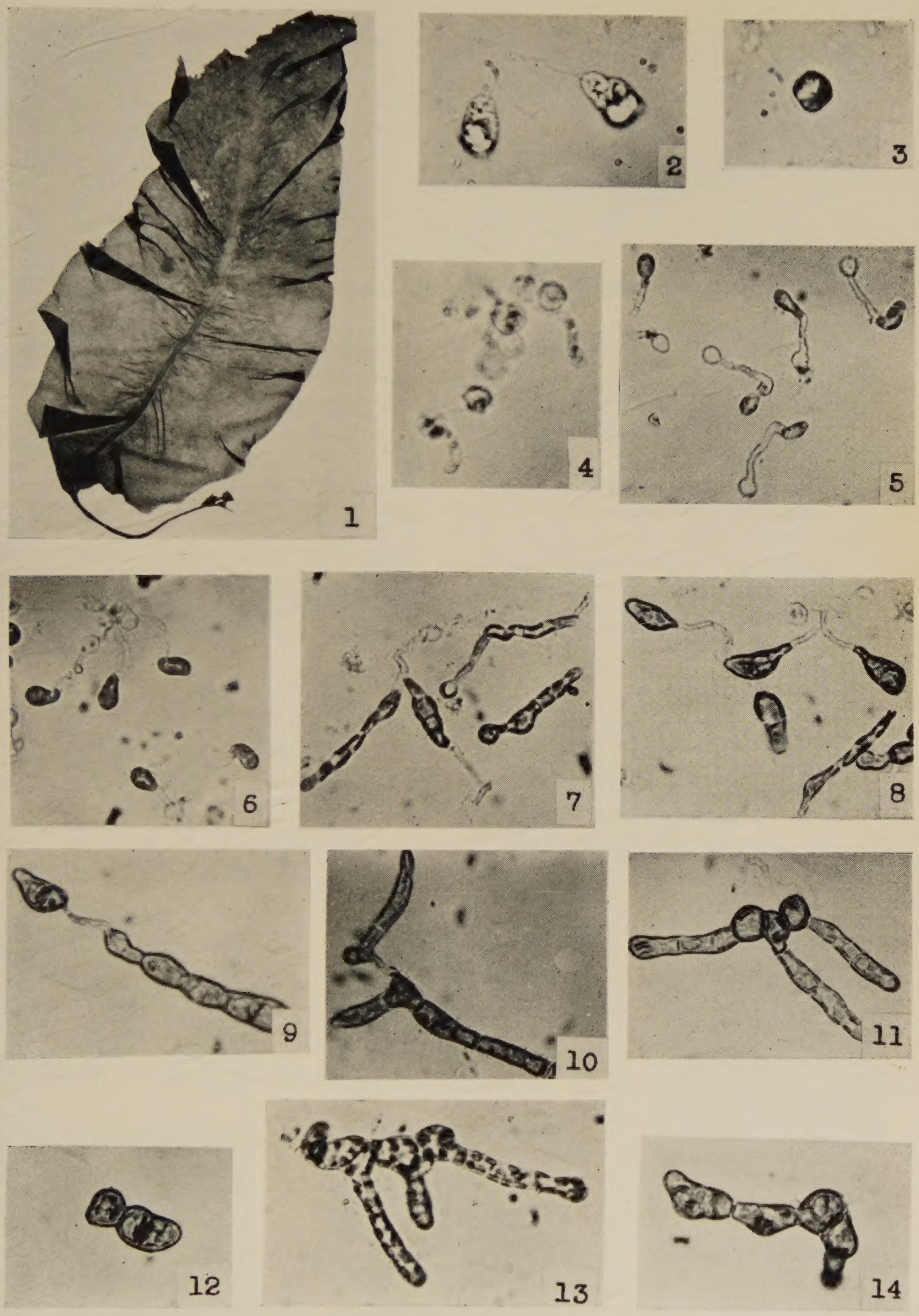
7–8. Gametophytes from a culture 10 days old. The sexual differentiation first becoming apparent. ×500.

9–11, 13. Male gametophytes from a culture 15–32 days old. ×500.

12. Female gemetophytes from a culture 20 days old. ×500.

14. Female gemetophytes from a culture 32 days old. ×500.

PLATE XXXIV



Explanation of the Plate XXXV

Undaria undarioides (YENDO) OKAMURA

1–2. Well developed male gametophyte. From a culture 35 days old. ×500.

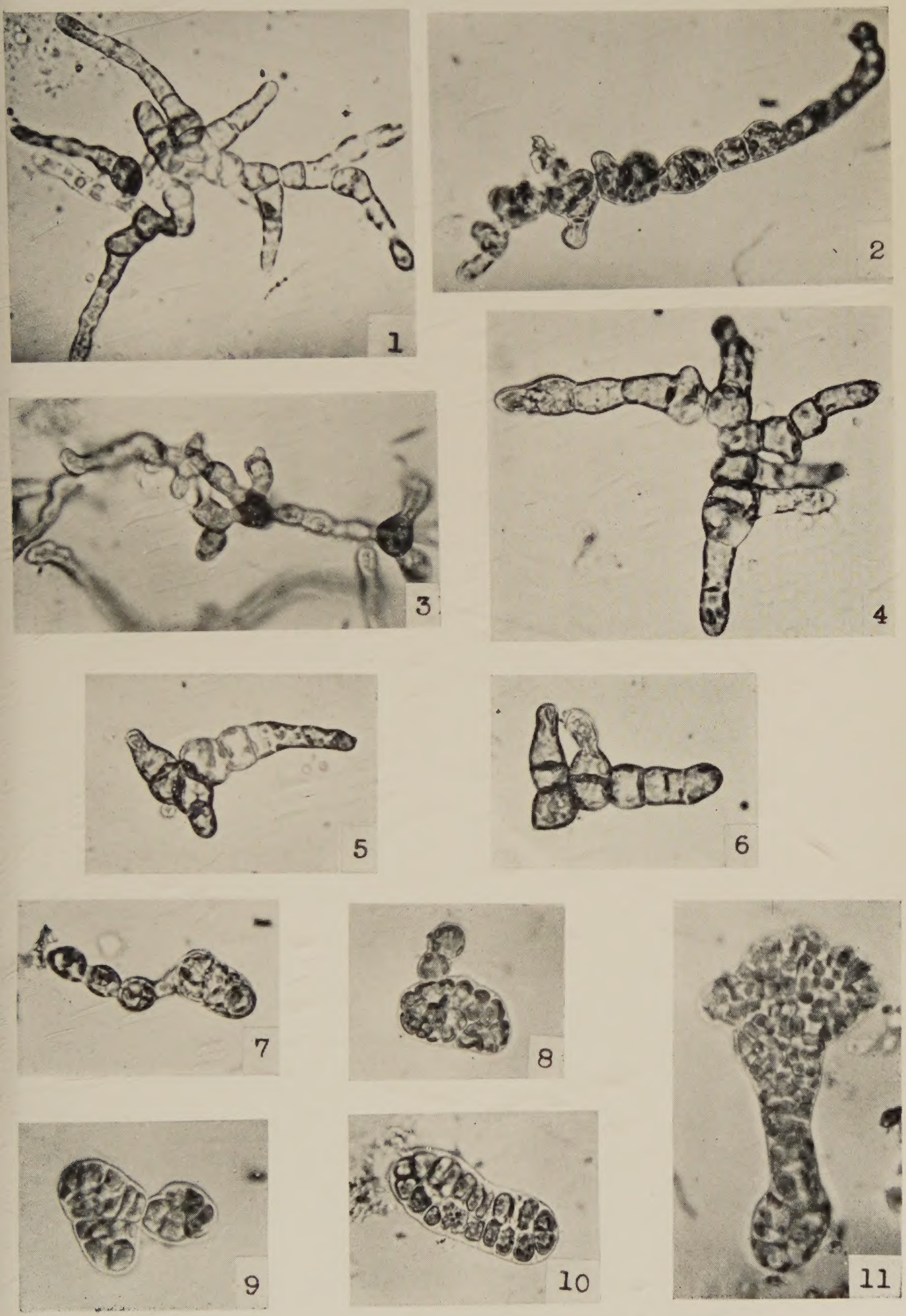
3. Male gametophyte with mature antheridia, in a culture 38 days old. ×500.

4. Female gametophyte consisting of 13 cells, from a culture 35 days old. ×500.

5–6. Female gametophyte at maturity. From a culture 38 days old. ×500.

7–9. Parthenogenetical developed female gemetophytes. From a culture 28 days old. ×500.

10–11. Parthenogenetical developed female gametophytes. From a culture 32 days old. ×500.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